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INTRODUCTION

National Wildlife Research Center— Mission and Location

The mission of USDA's Wildlife Services (WS) Program is to provide Federal leadership in managing problems caused by wildlife. The National Wildlife Research Center (NWRC) functions as the research arm of WS by providing scientific information on the development of socially acceptable methods for wildlife damage management. As part of WS' strategic plan to improve the coexistence of people and wildlife, it has identified four strategic program goals: (1) developing methods, (2) providing wildlife services, (3) valuing and investing in people, and (4) enhancing information and communication. WS is dedicated to helping meet the wildlife damage management needs of the United States by building on the Center's strengths in these four key areas. This annual NWRC research highlights is structured around these program goals.



The headquarters of the NWRC is located on 43 acres on the Foothills Research Campus of Colorado State University (CSU) in Fort Collins, CO. During 2002, NWRC made significant progress toward building out its Master Plan on that site. Construction was initiated on an outdoor animal research facility and associated research support structures, and on an office, lab, and animal food-storage and -preparation addition to the Center's existing indoor Animal Research Building. In addition, planning

was initiated on new facilities in which to conduct invasive species and wildlife disease research. Upon completion of the Center's Master plan over the next several years, NWRC and its United States regionally based field stations, will truly be the only wildlife research complex of its kind in the world devoted exclusively to providing new, science-based solutions to the complex issues of wildlife damage and associated human health and safety problems.



DEVELOPING METHODS

Goal: Increase effective methods available for wildlife damage management.

BIRD RESEARCH PROGRAM

Title: Economic Impact and Management of Bird Predation at Aquaculture Facilities in the Southeastern United States

Goal: Determine the magnitude of and develop methodology to reduce damage by cormorants, wading birds and pelicans on southern catfish, baitfish and crawfish farms.

Fish-eating birds can have a substantial economic impact on aquaculture production. Annual costs associated with bird damage and damage prevention for aquacultural industries are estimated to exceed \$17 million. Double-crested cormorants, American white pelicans, and several wading birds are the predominant species associated with these conflicts. In addition to conflicts with aquaculture,

double-crested cormorants have also been associated with habitat changes throughout North America. Present research is aimed at acquiring information regarding the abundance, foraging behavior, economic impacts, and damage management techniques associated with fish-eating birds near southeastern aquaculture facilities. Since these birds annually migrate from northern breeding areas to southeastern

wintering, these research efforts should provide the information necessary to develop and evaluate management alternatives throughout their range.

American White Pelican Ecology—During 2002, scientists at NWRC's Mississippi field station, in collaboration with biologists from the WS operational program, continued a banding study begun in 1996 of the breeding ecology of American white pelicans at Chase Lake National Wildlife Refuge in North Dakota, the largest known breeding colony of this species. The information is being used to develop models for describing the population dynamics of American white pelicans and to develop management strategies for reducing pelican damage to commercial aquaculture. By attaching coded, plastic leg bands to juvenile pelicans, Center biologists will be able to observe individual pelicans in subsequent years and learn about population parameters such as the age of first breeding, age-specific survivorship, and reproductive output. NWRC scientists also are using satellite telemetry technology to determine the distribution, abundance, movement patterns, and habitat use of American white pelicans in the





Southeastern United States. This study will provide information on pelican movement patterns throughout the region and their use of aquaculture complexes and other habitats.

Effects of Cormorant Foraging on Catfish Production—NWRC scientists conducted controlled foraging experiments at the NWRC captive bird facility on the Mississippi State University campus to assess the impacts of cormorants on catfish production. During these studies, cormorants consumed 7–9 catfish per bird per day. Relative to ponds without cormorant predation, this consumption resulted in a 30-percent reduction in fish abundance and a 23-percent loss in fish biomass. Based on these studies, it is estimated that the annual impact of cormorants to the aquaculture industry in

the delta region of Mississippi was near \$5 million (replacement cost) and could be as high as \$25 million.

A 2001 field study to determine the distribution and abundance of cormorants on catfish ponds in the delta region of Mississippi found that cormorants foraged daily on an average of 25 percent of the ponds aerially surveyed during the period February to April, with 5 to 46 birds counted using each pond. Cormorant feeding on aquaculture facilities was greater than the level of feeding simulated in the captive foraging studies, suggesting that the economic impact from this species may be greater than previously estimated. Future studies will focus on an increased understanding of population trends and cormorant breeding ecology to provide data essential for development of a scientifically

sound flyway management plan for reducing double-crested cormorant impacts to southern aquaculture.

Double-Crested Cormorant Population Model Provides Foundation for Evaluating Management Scenarios—

Scientists from NWRC and the United States Geological Survey's (USGS) Lake Erie Biological Station and the Canadian Wildlife Service have constructed a biological representation of cormorant population growth on Lake Ontario (1979–2000) by referencing literature values for fertility, age at first breeding, and survival. These parameters were incorporated into a deterministic stage-classified matrix model.

By calculating the elasticity of matrix elements (i.e., stage-specific fertility and survival), the researchers showed that cormorant population growth on Lake Ontario was most sensitive to survival of birds about to turn age 3 and older. Further, the investigators demonstrated how this information can be used to evaluate management scenarios and direct future research by simulating potential environmental effects on fertility and survival, as well as a 5-year egg-oiling program. They found that survival of older birds exerts more effective population control than changes in fertility. This population model is valuable to evaluate and defend management options for double-crested cormorants. The model was recently adapted for use by the Ontario Ministry of Natural Resources in its efforts to manage double-crested cormorants in the North Channel and Georgian Bay areas of Lake Huron.

Title: Development of Methods To Manage Depredation and Nuisance Problems Caused by Vultures

Goal: Understand the relationships between various habitat and land-use variables and problems caused by vultures and develop effective management techniques for reducing predation losses and property damage.

Vulture populations are increasing nationwide, particularly in the Southeastern United States. As vulture numbers increase, so do conflicts with human activities. Black vultures, for example, damage vinyl, plastic, and other synthetic construction and insulation material. Additionally, black vultures prey on newly born livestock and, in association with turkey vultures, form roosts that not only are nuisances (e.g., they can cause electric power outages) but also contribute to human health and safety problems. Vultures often forage at landfills, which in turn are often located near airports. In their daily flights to and from landfills to feed, vultures constitute a major hazard to aircraft. Problems related to vulture management show no sign of diminishing, and the need for efficient, practical, and safe methods of managing vulture damage situations is acute.

Eglin Air Force Base Vulture

Management Plan—In December 2001, pilots at Eglin Air Force Base, near Pensacola, FL, reported that increasing numbers of vultures soaring in the air space were creating unsafe conditions for air traffic at the base and at a colocated regional commercial airport. A wildlife biologist with NWRC's Gainesville, FL, field station evaluated the situation and identified a 250-bird vulture roost as the source of the problem. In cooperation with personnel at Eglin, WS personnel developed a management plan to disperse



the roost. One taxidermic vulture effigy was suspended from a prominent tree within the 125-ha roost area. To supplement the effigy, a hand-held laser was used briefly in the mornings and evenings. After 5 days, only 5 birds were observed in the roost; and 2 weeks later, no birds were using the roost. Dispersal of this vulture roost has both substantially reduced the potential for bird-aircraft interaction and demonstrates the effectiveness of this newly developed nonlethal method of vulture management.

Cattle Predation by Vultures—At a 2800-ha cattle ranch in Okeechobee County, FL, 20 cow or calf deaths have been attributed to black vultures annually through depredation of newborn calves, depredation

of incapacitated calving cows, and trampling of calves by cows charging at vultures. The problem probably was aggravated by the presence of a 4.5-ha vulture roost on the property. Ordinarily, several hundred black and turkey vultures occupied the roost, which consisted mostly of sabal palm and oak trees.

In an attempt to disperse the roost using a vulture effigy, a 14-m guyed aluminum mast was installed in the center of the roost and a taxidermic vulture effigy was suspended above the tree line. Prior to the installation of the effigy, 6 morning counts of vultures averaged 789 birds of which 74 percent were black vultures. On the morning after installation, the number of birds declined more than 80 percent, to 128 birds. By day 4, only 12 vultures remained, and their numbers remained that low through the next month. At that time, the mast-installed taxidermic effigy was replaced with a painted goose decoy and vulture activity remained suppressed. Since initiation of this management approach, the rancher has reported no vulture problems.



Title: Development and Evaluation of Management Techniques for Reducing Blackbird Damage to Ripening Sunflower Crops and Feedlots

Goal: Develop new and/or improved methods to reduce blackbird damage to ripening sunflower crops and feedlots.

Blackbirds and starlings are responsible for damaging grain crops and sunflowers and eating livestock feed. This research focuses on assessing the efficacy and environmental impacts of using DRC-1339 and repellants (e.g., anthraquinone) for reducing blackbird and starling populations and studying the environmental impacts and economics of using various lethal and nonlethal techniques to reduce bird damage.

Spring Dispersal Patterns of Red-Winged Blackbirds Staging in East-Central South Dakota—By early March, blackbirds usually begin migrating northward from their wintering sites in the Southern United States, stopping and roosting at preferred sites along the way. As the migration proceeds northward and birds establish breeding territories, these roosts become progressively smaller. Spring roosts consistently exceed 100,000 birds in east-central South Dakota but are usually much smaller north of this region. In April 2001, NWRC and North Dakota/South Dakota WS biologists aerially marked about 370,000 red-winged blackbirds in eastern South Dakota with fluorescent colors to determine their dispersal patterns as they continue north to their breeding grounds. During June, the biologists collected 4,458 birds (2,398 males and 2,060 females) on breeding territories in 56 random plots (1° latitude × 1° longitude) throughout the north-central United States and prairie provinces of Canada. Of these birds, 23 males and 10 females were marked. Based on the estimated population size in the

study area, the 0.74-percent recovery rate of marked birds was within expectations. The highest percentage of marked birds (82 percent) was found in sunflower-growing areas of North Dakota or in southern Canada. These results suggest that the majority of red-winged blackbirds staging in eastern South Dakota during spring migration are from a population that could cause significant damage to sunflower.

Avian Use of Roadside Habitat and Implications for Cattail Management—In 2001, NWRC and North Dakota State University (NDSU) biologists evaluated avian use of roadside rights-of-way in 30 quarter sections in the Southern Drift Plains of North Dakota to assess the potential of managing cattail stands along roadsides to reduce nesting by red-winged blackbirds and subsequent depredations on ripening sunflower crops. Farmers currently manage cattail-dominated wetlands near sunflower fields to reduce nesting and roosting by blackbirds. Roadside habitat along two 0.5-mile transects bordering these quarter sections was surveyed to assess avian use, and nest surveys were conducted to provide an index of use of various vegetation types by breeding birds. Nearly 40 different species were found using roadside habitats. About two-thirds of all birds identified were blackbirds, and more than 90 percent of active nests in the roadside habitat belonged to blackbirds. Thus, management of cattail stands along roadsides could potentially reduce blackbird nesting habitat and subsequent depredations to ripening sunflowers with minimal adverse impact on nonblackbird species.



Landscape Effects on Breeding Blackbird Abundance and Sunflower Damage in the Southern Drift Plains of North Dakota—Changes in local habitat variables, particularly the availability of cattails in wetlands, might have a pronounced influence on the annual populations of breeding blackbirds. This dynamic might influence the effectiveness of blackbird damage management techniques. To better understand the relationship between habitat availability and breeding blackbird numbers, WS and NDSU biologists conducted breeding blackbird surveys in 240 randomly selected quarter sections (65 ha) in the Southern



Drift Plains of North Dakota. In these same sample units, scientists also estimated bird damage to sunflower fields to develop a data-base of historical damage in relation to cattail-choked wetlands. An average of 17 adult male red-winged blackbirds, 16 yellow-headed blackbirds, and 4 common grackles per quarter section were observed.

Assuming a single male pairs with a single female, the biologists estimated the breeding population of blackbirds in the Southern Drift Plains to be 2.8 million birds. Blackbird damage to sunflowers during these surveys was estimated to be 6 percent of the crop and was valued at \$2.5 million.

Impact of Blackbird Damage to Sunflower: Bioenergetic and Economic Models—NWRC and NDSU scientists developed bioenergetic and economic models to estimate the impact of predation by red-winged blackbirds, common grackles, and yellow-headed blackbirds on sunflower production in the northern Great Plains. The models considered field metabolic rates, caloric value of seeds, percent of sunflower in diets, and moisture content of seeds to estimate the amount of sunflower consumed annually by each species and gender of blackbird. The model predicted that the amount of sunflowers consumed annually by males and females, respectively, was 265 g and 159 g for red-winged blackbirds; 257 g and 220 g for common grackles; and 237 g and 132 g for yellow-headed blackbirds. The annual damage value for males and females, respectively, was 9 cents and 5 cents for red-winged blackbirds; 8 cents and 7 cents for common grackles; and 8 cents and 4 cents for yellow-headed blackbirds. All three populations combined cause an estimated \$5.2 million worth of damage annually, or \$13.3 million based on lifetime damage values, to ripening sunflowers.

Title: Management of Bird Damage to Rice

Goal: *Develop new or improved management strategies for reducing bird damage to rice.*

Red-winged blackbirds, common grackles, and brown-headed cowbirds cause extensive damage to newly planted rice and ripening rice. This project research focuses on reducing bird damage to rice and improving profitability to growers by developing new or improved management strategies while expanding partnerships between rice producers, rice commodity groups, rice research boards, universities, and local, State, and Federal agencies.

Blackbird Foraging Behavior on DRC-1339 Bait Sites in Louisiana—DRC-1339

is a highly effective and selective avicide for reducing populations of blackbirds that damage agriculture crops such as rice. To better determine blackbird consumption and mortality during DRC-1339 baiting operations, NWRC scientists analyzed the esophagus and gizzard contents from birds collected as they departed 12 DRC-1339 bait sites in Louisiana. The following tabulation documents grain consumption rates by species and gender.

Grains of rice consumed, by bird species and gender

Bird species	Males	Females
Red-winged blackbirds (524)	32	26
Brown-headed cowbirds (45)	36	33
Common grackles (27)	69	77
Yellow-headed blackbird (1)	—	61

By ranking blackbirds by species and rice grain consumption, estimates of take can be calculated. For example, foraging behavior of red-winged blackbirds on bait sites showed that 6 percent of the redwings consume no rice grains, 56 percent consume between 1 and 25 rice grains, and 38 percent consume >25 rice grains. Redwings that consumed <25 rice grains consumed a total of 3,146 rice grains whereas redwings that consumed >25 rice grains consumed a total of 11,001 rice grains. These numbers and other

parameters such as species, sex, bait distribution, and concentration level are being included in a predictive model for estimating the take of blackbirds from baiting operations.

Alternative Formulations for DRC-1339

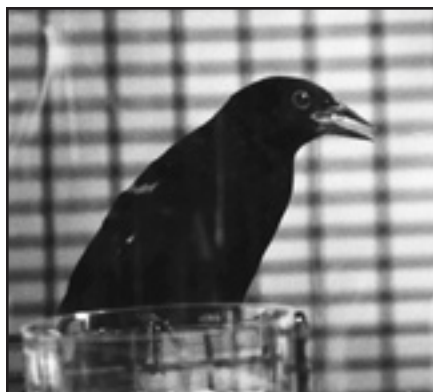
Baits—Rapid deterioration of baits is a major impediment to the success of DRC-1339 baiting programs to reduce depredating populations of blackbirds. The standard DRC-1339 bait commonly used in operational baiting programs usually



discolors (degrades) within 1 day, resulting in reduced consumption by birds. NWRC researchers conducted a series of cage and field tests to evaluate the chemical degradation and acceptance by red-winged blackbirds of various tablet and extruded formulations that might provide a more effective alternative to the currently used bait. The tablet baits evaluated by the researchers consisted of two sizes (12 or 18 mg), contained 60 percent brown rice flour mixed with or without calcium, and were of three different colors (white, light grey, or yellow).

There was little to no discoloration of any of the tableted baits for up to 7 days. The tablet combination, 12 mg, light grey, containing calcium was the most preferred by redwings and cowbirds. However, overall consumption of this tablet in the field was only about 40 percent.

The researchers also evaluated different extruded baits made from various wheat, corn, rice, semolina, and processed white flour, combined with additives such as phosphoric acid, ascorbic acid, and escalo 567 and 557 to stabilize the degradation of DRC-1339. Red-winged blackbirds showed a preference for the extruded baits that were combined with wheat flour and



phosphoric acid. However, the extruded baits deteriorated rapidly under field conditions. NWRC scientists plan additional tests to evaluate additional formulations for improving the durability and acceptance of DRC-1339 baits.

Blackbird Bait Preference for Rough Rice, Brown Rice, and Millet—

Development of effective blackbird baiting strategies is influenced by many factors, including preferences for different seed types by individual red-winged blackbirds. Biologists at the NWRC's Gainesville, FL, field station conducted feeding trials with individual blackbirds to document preferences among three seed types: rough

rice, brown rice, and millet. Individual birds were exposed to pairs of seed types, and preference scores were calculated based on the amount of each seed type consumed. A strong preference was displayed when >80 percent of total consumption was of one seed type or the other. Each pairing of seed types was presented to 17 birds.

When rough rice was paired with brown rice, six birds showed a strong preference for rough rice while four had a strong preference for brown rice. When rough rice and millet were presented, nine birds showed a strong rough rice preference whereas three had a strong preference for millet. When millet was paired with brown rice, five birds strongly preferred millet whereas seven had a strong brown rice preference.

Taken together, these results show that most blackbird species demonstrate definite seed preferences that vary among individual birds. In the context of blackbird baiting strategies, these findings indicate that a mixture of bait types might be more effective than a single bait type, a conclusion consistent with results obtained in other feeding trials by NWRC biologists in North Dakota.

Title: Defining and Reducing Wildlife Hazards to Aviation

Goal: Provide a scientific foundation for WS programs at airports throughout the United States to reduce wildlife hazards to the aviation industry.

To be certified for passenger traffic by the Federal Aviation Administration (FAA), most United States airports are required to have wildlife hazard-management plans in place. In addition, the FAA has strict standards regarding bird strike capabilities of aircraft engines and the siting of wildlife attractants such as waste-management facilities near airports. An interagency agreement between NWRC and the FAA was established in 1991 to provide the FAA with scientific support for recommendations and policies to control wildlife hazards to the aviation industry. These wildlife hazards are primarily caused by federally protected bird species, although certain mammals such as deer can also be a problem. Research and information needs cover a broad spectrum of topics related to understanding the nature of wildlife hazards at airports, developing management tools that will reduce these hazards, and providing airport personnel with information on the latest strategies for controlling wildlife hazards.

Development of the National Wildlife Strike Database—Through an interagency agreement with the FAA, NWRC's Sandusky, OH, field station has developed a national database of more than 41,000 reports of bird and other wildlife strikes with civil aircraft from 1990 through 2001. The database provides critical information to airport operators, biologists, aeronautical engineers, and regulators in designing programs, policies, and aircraft components to reduce damaging wildlife strikes.

Since 1995, the database manager at the Sandusky field station has responded to more than 600 requests from WS biologists for information on wildlife strikes at various airports in the United States. To make strike reporting easier and information from the

database more accessible to the aviation community and wildlife biologists working at airports, the FAA has contracted with Embry-Riddle Aeronautical University, Prescott, AZ, to host a Web site that will allow online reporting and database queries.

During 2002, two professors from the university visited the Sandusky field station to begin work on conversion of the database to a new software system and to update the strike-reporting form. The new system is now available and online. Strikes can be reported online at <http://wildlife-mitigation.tc.faa.gov>.

Age-Specific Reproductive Rate of Laughing Gulls—Important life-history parameters that are poorly understood for most bird species are the age at which

reproduction first occurs and the percent of the population in each age class that breeds annually. WS biologists have shot gulls at a large northeastern airport since 1991 as part of an NWRC-developed program that has reduced bird strikes at the airport by more than 50 percent. By examining plumage characteristics from known-aged (banded) gulls shot at the airport, NWRC biologists have developed a technique to determine the age of laughing gulls at 0, 1, 2, and 3 or more years old. Furthermore, based on the examination of postovulatory follicles in ovaries of female laughing gulls shot at the airport in 2000 and 2001, NWRC biologists determined the percent of females laying eggs in each age class. The study determined that 54 percent of 2-year old females and 88 percent of females 3 or more years old had laid eggs, indicating that



nesting birds from a nearby colony were frequenting local airspace.

This is the first documentation of nesting by 2-year old female laughing gulls. (None of the 1-year old gulls showed evidence of nesting). This information is of critical value in predicting the population response of gull populations to various management programs involving lethal or reproductive control.

NWRC Study Documents Effectiveness of ElectroBraid™ Fencing as Barrier to White-Tailed Deer

The white-tailed deer population in the United States has increased from 350,000 in 1900 to more than 26 million deer in 2002, creating many crises in public safety and conflicts with agriculture. For example, more than 500 civil aircraft collisions with deer were reported from 1990 through 2001. Exclusion of deer from the impacted area using 10-foot-high chain-link fencing is the standard long-term solution, but high cost makes this option impractical for most small airports and agricultural crops. An inexpensive deer-exclusion system would have many uses to minimize conflicts between deer and humans.

One potential system is an electric fence composed of copper wires braided into polyester rope. Such braiding allows high conductivity of electricity. During 2002, in cooperation with ElectroBraid™ Fence



Ltd of Dartmouth, Nova Scotia, NWRC biologists evaluated the effectiveness of a five-strand braided fence to exclude white-tailed deer in two experiments at the 2,200-ha National Aeronautics and Space Administration Plum Brook Station in northern Ohio. Deer intrusions were measured at 10 pairs of fenced sites with and without electricity where corn was provided in feed troughs. In both 1- and 2-choice tests, less than 1 deer per day crossed into sites with electrified fence

compared to 85 per day in sites without electricity.

Trials were also conducted that demonstrated the frangibility (breakability) of the plastic posts used to support the fencing. The FAA requires a demonstration of frangibility before such fencing can be installed near runways on airports. These tests indicated that deer were deterred from desired food by ElectroBraid™ fencing and that the plastic posts readily broke when struck by a vehicle.

Title: Emerging Technologies To Resolve Human–Wildlife Conflicts: Cell Culture, Repellants, Antisweet and Antinutrient, and Behavioral Methods

Goal: Discover new technologies and adapt existing methods for the development of nonlethal methods in the resolution of conflicts between humans and wildlife.

Despite considerable demand for nonlethal methods of animal damage management, few effective chemical repellants and selective attractants exist for most applications. Fundamental physiological data concerning olfaction, taste, and trigeminal chemoreceptive abilities of wildlife are largely nonexistent, and the application of existing behavioral data to enhance wildlife control technologies is lacking. This project investigates the chemosensory morphology, histology, and physiology of sensory system function in several wildlife species important to the WS program

Changing the Palatability of Grass to Geese—Geese show clear foraging preferences for different grass varieties. This follows the general herbivore pattern that correlates low silica content of forage with palatability. Unfortunately, grass varieties that have high silica content often are not preferred for esthetic reasons by humans. NWRC scientists investigated whether preferred varieties of grass, such as Kentucky bluegrass, fescue, and rye, can be induced via fertilization to express higher silica content. Silica content of fescue and rye were only marginally increased when hydroponically grown in the presence of calcium silicate fertilizer. Silica content of Kentucky bluegrass was increased by 400 percent when hydroponically grown in the presence of calcium silicate. However, because the silica content of Kentucky bluegrass is so low to begin with, the question remains whether this increase is sufficient to change the palatability of the



fertilized grass to grazing geese. Answering that question is the focus of current research. If successful, this method holds promise of altering the palatability of a grass variety to geese that is culturally preferred by humans.

Natural Products as Avian Repellants—Previous studies attempting to relate structure and repellant activity have focused on five- and six-member ring aromatic structures. Many of these compounds are derivatives of natural flavor ingredients. However, little is known about the avian repellant activity for other common chemical structures are derived from natural products, such as terpenes. This diverse class of compounds is one of the most common plant chemicals, and lack of

knowledge about the bird repellant activity of these structures is a significant gap in the knowledge of bird repellant structures. This problem is especially noteworthy because these compounds are the basis of many plant chemical defenses.

During 2002, NWRC scientists completed initial bird repellant screening of citral-like compounds. Most of the compounds functioned as moderately effective primary repellants. However, serial testing revealed that intermittent exposure of these chemicals to birds resulted in significant improvement in repellant activity, suggesting the utility of these compounds may lie in their ability to function as secondary repellants.

MAMMAL RESEARCH PROGRAM

Title: Developing Tools and Strategies To Reduce Mammalian Impacts on Forest Resources

Goal: Provide feasible nonlethal solutions and improved rodenticides for forest managers to resolve problems encountered with selected wild mammals.

Foraging wildlife affects forest resources in numerous ways. Damage can result in reduced productivity, delayed harvest cycles, failure to replace trees after a harvest or a fire, or failure to establish native plants. Managing resources to resolve these problems is becoming increasingly difficult because the land base to produce timber is shrinking, reducing management options while increasing the necessity to protect remaining resources. This project is addressing the critical need for enhanced research and outreach programs to develop new nonlethal approaches and improve existing approaches.

Bear Response to Supplemental Feed Offered To Reduce Tree Peeling—Black bears strip bark from coniferous trees to feed on vascular tissue during spring. Damage inflicted through this behavior can be extremely detrimental to the health and economic value of timber stands. Timber managers in western Oregon expend about \$500,000 a year to prevent bear damage, yet bears continue to inflict damage sufficient to cause substantial economic consequences. Aerial surveys indicate that roughly 26,000 ha are affected by bear damage in western Oregon.

Assuming a moderate stocking rate of 300 trees/acre and bear peeling on 4 percent of the trees, then 768,000 trees (300 trees/acre \times 64,000 ac \times 0.04) are killed annually by bears. If a value of \$15 per tree is assigned, and if the average tree age is assumed to be 25 years, the annual estimated loss would be \$11.5 million.



Another survey in western Washington evaluated potential loss if no preventive measures were implemented on 40,000 ha of industrial timberland. Using similar calculations as described for Oregon the annual estimated loss is about \$23 million.

A supplemental feeding program to provide bears an alternative food rather than peeled tree bark is practiced by some forest managers. NWRC evaluated the efficacy of the feeding program and conducted concurrent studies to assess behavioral characteristics of feeding bears and impacts of providing supplemental feed on the nutritional status of bears. An efficacy study revealed the percentage of damaged trees in stands with foraging bears varied from 2 percent to 52 percent. When supplemental feeding was introduced on these stands, damage was reduced to approximately

10 percent of that sustained on untreated stands.

Concurrent experiments showed that numerous bears, including females with and without cubs, yearlings, and boars, fed at the stations. Bear feeding sessions at these stations lasted generally less than 30 minutes. Bears usually fed alone, but two to three adult bears were sometimes observed at a feeder simultaneously. Bear behaviors in the vicinity of feeding stations suggest that bears were not competing with each other for this nutritional resource. Little antagonistic behavior was observed at the feeders, indicating that this behavior did not inhibit foraging opportunities—perhaps because unlimited food was made available at the feeders. While supplemental feeding did not affect the size of bears' home range in feeding areas, it may serve to concentrate bears in particular locations. Bears consuming supplemental feed did gain a significant nutritional advantage while feeding, but this did not equate to long-term increases in age-specific body masses or fat content.

Understanding Mountain Beaver Movements and Home Range Use in an Effort To Minimize Forest Damage—

Wildlife damage to tree seedlings is an impediment to reforestation efforts in the Pacific Northwest, and hundreds of thousands of dollars are spent annually to control mountain beaver. This beaver is a semifossorial rodent, endemic to the Pacific Northwest, that causes retarded growth, seedling deformities, and mortality

by its feeding activities. Even after intensive removal of mountain beavers from an area, they quickly reinvade seedling areas from surrounding habitats. Managing mountain beaver requires knowledge of its biology and habitat use—information that is currently lacking.

In 2002, a study was conducted to estimate these home range size and areas of use by mountain beavers and to determine their dispersal movements. Thirty subadult and adult mountain beaver were radio collared, and their activity patterns in two recent clearcut areas on the Weyerhaeuser Twin Harbors Tree Farm in Montesano, WA, were monitored. Animals were tracked hourly throughout a 24-hour period at least three times a week.

Mountain beaver were found to be active for brief intervals throughout a 24-hour period, contrary to previous literature that suggested they were active only during the night. Preliminary results also suggest that mountain beaver have larger home ranges than the 0.12–0.2 ha previously described. Although only a few yearlings were radiocollared, dispersal of yearlings >300 m from their natal territories was documented. It appears that yearlings stay near their birth site until the next year's pups are born, at which time the yearlings disperse.

Developing Nonlethal Tools and Strategies To Reduce Beaver Damage to Wetland Restoration Sites—The Tres Rios project, supported by a major southwestern city, is working to restore critical riparian and wetland habitats that have been lost in the region as a result of water resources development in the metropolitan area. The project has been highly successful in establishing small wetland habitats occupied by a variety of flora and fauna. However, excessive beaver activity at these sites has become destructive. Although the Tres Rios managers recognize that beaver activity needs to be suppressed, they do not consider lethal removal a viable option.



Capture and removal also is not a viable management option because of restrictions imposed by the State's department of game and fish. NWRC scientists have begun a series of studies to identify and evaluate nonlethal approaches for beaver damage management in urban and wetland restoration areas.

The first phase of the research investigated candidate tools to protect bulrush and cattails from beaver. Techniques tested were cyclone fencing to prevent beaver access, an electronic beaver guard, and a frightening device with a flashing light. The 0.95-m-high cyclone fence enclosures were constructed with 2-m metal T-post and woodland-green vinyl-coated, 5-cm mesh, 9-gauge chain-link fence. Frightening devices were created by attaching a CritterGitter® to a 4- x 4-inch post below a flashing light. The CritterGitter® was secured to a flotation platform to keep its motion detectors a few centimeters above water level. The electronic beaver guard consisted of an electro-shocking device, previously developed by NWRC for beaver dispersal

in water and modified to be triggered by the frightening device. When the device is activated, the surrounding water receives a low electrical current, that causes a mild shock. A switch operated by remote control activates the device. Cottonwood stems on terrestrial lots were protected by the same devices, except a textural repellent was used instead of the electro-shocking device. The textural repellent, a simple mixture of 70-mm sand and alkyd paint (140 g/L) also was developed by NWRC scientists.

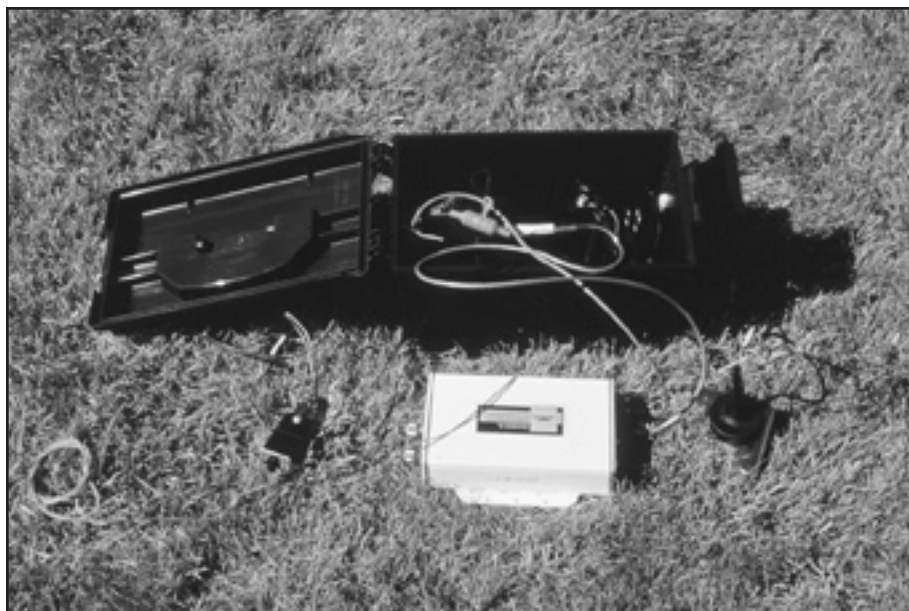
Fencing plots offered the best protection. Mammals did not penetrate the barriers, but many birds were observed inside the enclosures. Frightening devices did not appear to hinder the presence of target or nontarget species. The electro-shocking device and textural repellents deterred animals for a while, but animal presence and damage increased over time. Observations revealed 70 bird species, 11 mammal species, and 5 amphibian and reptile species visited plots during this study.

Title: Alternative Capture Systems and Aversive Stimulus Applications for Managing Predation

Goal: Identify, develop, and evaluate advanced capture systems and aversive stimuli applications for predation management emphasizing animal behavior and engineering approaches.

In Europe and the United States, large predators are returning to former habitats that are now also populated with people and livestock. Public and professional concern for animal welfare and a simultaneous requirement for a stable and affordable food supply have led to intense pressure on wildlife managers to find immediate solutions when humans and wildlife adversely interact. However, capture technologies are largely reliant on tools and materials that were developed hundreds and thousands of years ago. These older technologies are still widely used because extensive use has honed and proven their effectiveness and there are few other options commercially available. The current project is attempting to develop new and alternative techniques for minimizing adverse interactions between predators and livestock.

Operational Use and Evaluation of the Radio Activated Guard—NWRC and WS Idaho State office biologists evaluated the operational use of radio activated guard (RAG) devices for nonlethal control of wolf predation in 2002. The RAG is a radio-activated scare device that activates a strobe light and recordings of loud noises



when triggered by a radio-collared wolf. To date, 11 devices have been produced and deployed.

The devices were used to successfully protect cattle on private lands in Idaho from repeated incursions by wolves. But after numerous months of deployment, one pack habituated to the devices and they were no longer a deterrent. However, this nonlethal

technique was effective for longer than any previous technology.

The RAG concept, designed by NWRC scientists, is now commercially available and is being employed and integrated into predepredation proactive wolf management by WS operations with support from nongovernmental organizations such as Defenders of Wildlife.

Title: Ecology, Behavior, and Management Methods for Predators To Protect Livestock and Wildlife Resources

Goal: Examine the ecology, behavior, and management of predators in relation to depredation on livestock, game animals, and threatened and endangered species.

Data on predator population dynamics, ecology, and behavior in relation to predation patterns on species of human concern (mainly livestock, game species, and threatened and endangered species) are needed for effective depredation management. These data can also be used as a basis for developing accurate methodologies of indexing predator abundance and monitoring programs. While much data exists, significant gaps remain with regard to predator–prey,

predator–predator, and predator–livestock relationships. In addition, despite increasing interest in selective attractants for the delivery of pharmaceutical materials, repellants, and deterrent strategies that can reduce depredation, few practical alternatives exist.

Role of Coyote Predation in Swift Fox Population Ecology—The swift fox was once distributed throughout the shortgrass prairie of North America. Today, the swift

fox exists only in the southern and central portion of its historic range. Causes of this population decline include hunting, trapping, poisoning, and habitat loss. Predation by coyotes is now being cited as a major cause of mortality of adult and juvenile swift foxes.

Predator control has been used to enhance other species populations but is controversial and has had conflicting results. Biologists examined the extent to which swift fox populations are influenced by coyotes and if coyotes are a limiting factor of swift fox populations in southeastern Colorado. Between 1998 and 2000, 124 coyotes were removed from a portion of the study area while another area received no coyote control. Across the study area, 141 adult and juvenile swift foxes were monitored. Periodical surveys were conducted to assess the abundance of predator and prey species in the community.

Removal of coyotes resulted in no changes in swift fox home-range size, reproduction, social unit size or organization, or activity patterns. Juvenile fox survival increased but was compensated for by increased juvenile dispersal, resulting in no net gain in fox density in the removal area as compared to the nonremoval area.



Title: Selective Targeting of Adult Territorial Coyotes To Manage Sheep Depredation: Efficacy and Methods

Goal: Determine the efficacy of selective removal of adult territorial coyotes whose space overlaps pastured sheep as a strategy to reduce depredation losses, and determine how to selectively target these coyotes.

Developing acceptable strategies and methods to reduce livestock losses by coyotes is critical. Removal of coyotes from livestock operations is the most widely used strategy for coyote control at present. This project research is directed at developing better and more selective methods to reduce predation.

Avoidance of Control Devices by Alpha Coyotes—NWRC research has shown that relatively few coyotes in an area kill sheep. The principal killers are the alpha coyotes whose territories overlap sheep pastures, particularly those with lambs. Research has also shown that the selective removal of one or both alpha coyotes stops depredation in their territory for about 3 months, until a new alpha pair becomes established. Alpha coyotes are more difficult to capture or otherwise remove than either beta or transient coyotes in their territories. Evidence indicated that alphas were the only truly territorial coyotes, suggesting that their greater wariness toward control devices is somehow related to being able to distinguish familiar from foreign objects and/or to a greater likelihood of detecting human activity associated with placement of the devices.

These findings point to the need for developing nonlethal and lethal control methods that effectively target the alpha coyotes. A better understanding is needed of the behavior of alphas toward control devices. In a field study undertaken at the Dye Creek Preserve in northern California, a high density of photo-trap cameras was placed in five territories in which coyotes of

known social status had been outfitted with color-coded collars.

All coyotes were found to be wary of cameras, leading to relatively low numbers of photo-captures, most of which occurred at night. Alphas were photo-captured on only 3 occasions and never within their own territories, compared with 103 photo-captures of betas and transients. The study therefore showed that social status affected the vulnerability of coyotes to simulated capture with infrared-triggered camera systems.

Next, it became important to determine how alphas were able to avoid the camera traps within their own territories. Daytime observation and nighttime radio-tracking indicated that alphas continued to use their entire territory and did not avoid areas with camera stations. Radio-tracking coyotes prior to and during camera setup showed

that alphas either approached to within a safe distance or moved to a vantage point from where they could observe the researcher. Following setup, they then followed the researcher away from the camera station. Betas and transients did not track the researcher. These facts suggest that alphas learned the locations of the camera stations as they were being set up and subsequently avoided them. They also suggest that alphas were wary of camera stations both because they were novel objects and they had human activity associated with them. These results offer an explanation as to why resident coyotes—particularly alphas—are difficult to capture within their territories and also why they are underrepresented in scent station surveys. In addition, the results suggest that delivery of control tools to alphas (i.e., chemical sterilants) may be difficult to achieve.



Title: Holistic Management of Rodents and Other Vertebrate Pests

Goal: Develop safer and more effective methods to reduce the agricultural, natural resource, and human health impacts of rodents and other introduced pests in Hawaii.

Rats cause significant agricultural, natural resource, and human health impacts to the Hawaiian Islands. Where they are used, current control techniques provide inconsistent levels of protection from rodent impacts. NWRC biologists conduct field and laboratory research to identify, evaluate, and improve methods, materials, and devices to reduce and monitor rodent impacts on Hawaiian crops and natural resources.

A Simulation Study of the Broadcast Application of Rodenticide Bait in a Native Hawaiian Forest—Rodent control is a high priority for many species and ecosystem restoration plans in Hawaii. In 1995, a State registration for the use of anticoagulant bait blocks in bait stations to reduce rat depredation in Hawaiian native ecosystems gained regulatory approval. A broad coalition of Federal, State, and nongovernmental wildlife-management agencies and private industry is currently collaborating to obtain an aerial broadcast registration for rodenticide use in conservation areas. An essential research study—an assessment of the relative risk that the broadcast application of rodenticide bait poses to Hawaiian forest bird communities—in support of the broadcast registration, is being completed by scientists at NWRC's Hawaii field station. Fieldwork for this study has been completed in three different forest habitats on the islands of Hawaii and Maui using two different formulations of placebo bait.

Scientists currently are assessing Hawaiian birds' bait acceptance by comparing placebo bait uptake to the relative abundance of specific avian species within the avian community, using infrared



monitoring and camera equipment. With data from three of eight replicates analyzed (approximately 7,600 photos showing vertebrate bait consumption) only 85 photos from 1 site documented bait consumption by a single avian species, the introduced red-billed leiothrix. Rats were documented consuming bait 7,500 times. To date, these data suggest that there is a relatively low risk to native Hawaiian forest birds from the broadcast of pelletized rodenticides. Data will be used to support efforts to obtain regulatory approval of the aerial



broadcast application of rodenticide bait for conservation purposes in the State of Hawaii.

Efficacy of Caffeine To Control Introduced Frogs in Hawaiian Floriculture and Nursery Crops—Two species of *Eleutherodactylus* tree frogs native to the Caribbean, the coqui and the greenhouse frog, have become established in the Hawaiian Islands. Since their introduction via the import horticultural trade (probably about 1988), the frogs have rapidly expanded their range on the islands of Hawaii, Maui, Oahu, and Kauai.

There is a concern by Federal, State, and private agencies in Hawaii that introduced *Eleutherodactylus* frogs pose a serious threat to natural and agricultural resources. Coqui frogs can reach densities of greater than 24,000 per ha and are capable of consuming 114,000 arthropod prey items/ha in a single night in its native range in Puerto Rico. It is believed that tree frogs, once established in native habitats, could prey on endemic arthropods as well as compete indirectly and directly with native birds for limited food resources. Tree frogs may also be a vector for plant nematode eggs, and the recent discoveries of frogs in certified nurseries make the frogs a potential quarantine issue that could greatly impinge on the exportation of disease- and pest-free nursery products within and from the State.

Localized loud vocalization of male frogs (80–90 dB) throughout the nighttime hours has also been a source of numerous angry complaints from sleepless residents and tourists alike.

The relative abundance of introduced tree frogs in the study sites was determined using three independent techniques: (1) *Eleutherodactylus* relative abundance, (2) frog chorus volume, and (3) trap occupancy rate. The directed spray application of 0.5-percent, 1.0-percent and 2.0-percent caffeine solutions reduced *E. coqui* abundance in test situations on or bordering infested ornamental plant nurseries. This pattern of frog population reduction was substantiated by all three independent indices of frog abundance on three of seven study sites and by using two independent indices of frog abundance on the other four study sites. Treatment of plots with a single spray application of a 2-percent concentration caffeine solution caused a 100-percent decline in the relative abundance of frogs. The Hawaii Departments of Agriculture and Land and Natural Resources have submitted the caffeine data in a requested Emergency Use Permit with the Environmental Protection Agency (EPA) to allow the spray application of caffeine in sites infested by introduced tree frogs. These departments are leading a coordinated effort to control introduced tree frogs in Hawaii.

PRODUCT DEVELOPMENT RESEARCH PROGRAM

Title: Improved Assessment, Sampling and Economic Methods for Wildlife Damage Management

Goal: Develop and validate new techniques to assess, sample, and quantify wildlife damage management, plus determine related benefits and costs.

This project is attempting to quantify benefits and costs of both new and traditional wildlife management activities. Research addresses the real costs and returns of intervening with repellants, relocations, removals, rodenticides, etc., to limit the adverse effects of wildlife on agriculture, natural resources, and public health.

Economics Research Ideas From NWRC and WS—In 2001, letters were sent to WS regional and State directors and NWRC scientists asking them to identify potential collaborative research efforts dealing with the economics of wildlife damage management. Twelve respondents identified 25 specific topics related to 8 general economic issues needing analysis. These issues included economic analysis of predator management to protect endangered species, pre- versus posttrap ban analysis, reproductive inhibition, wildlife disease management programs, predator management to enhance game and nongame species, beaver damage management, indirect losses by birds at feedlots, and humane trap checks. As a result, NWRC scientists are collaborating with WS operations personnel in (1) evaluating the role of WS in endangered species recovery efforts, (2) assessing how well WS personnel have adjusted to public initiatives limiting the use of leghold traps and toxicants for wildlife damage management, and (3) predicting the potential benefits and costs of creating a barrier to the westward progression of raccoon rabies.

Economic Analyses of Four Approaches for Predator Management To Protect Sea Turtle Nests

—An analysis of the economics of protecting endangered sea turtles at Hobe Sound National Wildlife Refuge in Florida used a decision tree to map the loss values for each of three turtle species (Atlantic green, loggerhead, and leatherback). Turtle valuations were based on Florida penalties for harming or killing one of the animals (\$100 each—a low, conservative value). The refuge provides undisturbed nesting habitat for these three species of threatened or endangered marine turtles. Control of raccoons and armadillos has been identified as the most important management tool for enhancing nesting productivity.

Estimates of the number of nests that would have been lost in the 2000 reproductive season were made using the results from four predator management approaches: (1) some predator control by refuge personnel, enhanced by a one person-month contract with Federal control specialists, with predator population monitoring; (2) some predator control by refuge personnel, enhanced by a one person-month contract with Federal control specialists, without predator monitoring; (3) control by refuge personnel, without contract with specialists; and (4) no control. Approach 1 resulted in the fewest turtles lost to predation. Approach 1 also had by far the best benefit–cost ratio for loggerhead turtles (\$3,325,566 in prevented losses), but approach 2 was best for Atlantic green and leatherback turtles (\$197,666 and



\$44,366, respectively). However, almost 90 percent of the turtles nesting at the refuge are loggerhead, and the refuge is vital to loggerhead survival. Thus, approach 1, which cost \$5,000, also had by far the best benefit–cost ratio across all turtle species, saving approximately \$1.7 million over approach 2, \$2.6 million over approach 3, and \$8.4 million over approach 4. These results demonstrate how decision tree analysis can help provide economic data on which to base predation management strategies.

1998 California Trap and Toxicant Ban Data Set—Public initiatives to ban leghold traps have been enacted in Arizona, California, Colorado, Massachusetts, and Washington. In 2002, NWRC economists began collaborations with WS specialists to attempt to quantify how these initiatives have affected the WS program. Data for California were obtained from the WS Management Information System Support Center files. Analyses of these data are intended to clarify how WS personnel adjusted to prohibition on uses of the leghold trap, the M-44, and the ban on the use of the livestock protection

collar ban. Economic analyses compare coyote management methodology and effort expended before and after the trap ban. Data from 1997–98 (pre) are being compared to those for 1999–00 (post).

Although only preliminary analyses have been conducted thus far, major adaptations on the part of WS Specialists are evident for livestock protection. Data from before the ban showed that 60 percent of coyotes were removed via leghold traps and M–44s; after the ban, data demonstrated that 85 percent of coyotes were removed with the use of neck snares and “calling and shooting.” These latter techniques, especially calling and shooting, are much more labor intensive than the leghold trap or M–44.

Economic Response Surfaces Help Decisionmaking To Control Raccoon Rabies—NWRC researchers have developed a computer program to make iterative calculations of direct benefit–cost ratios tied to key variables that determine the effectiveness of WS oral rabies vaccination intervention to control raccoon rabies. Plots of these benefit–cost ratio surfaces allow examination of the minimum

and maximum returns on investments that key technique and application factors play in these control activities.

In 2002, NWRC began looking at the benefits and costs of the WS program of creating a barrier to the spread of raccoon rabies via wide-scale oral vaccinations with Raboral V-RG®. Multiple scenarios of potential costs, potential savings, and potential effectiveness were programmed. Input variables included a range of possible bait costs, aerial distribution costs, vaccination effectiveness, and postexposure prophylaxis savings in the events of rabies outbreaks. Most of these factors were based on actual known costs of baits ($\approx \$1.50/\text{bait}$) and aerial distribution ($\approx \$8.52/\text{km}^2$), with potential effectiveness treated as a percentage of savings from hypothetical postexposure prophylaxis amounts (e.g., \$20 million, \$40 million). Computations of direct benefit–cost ratios associated with aerial baiting (by fixed and rotary wing aircraft) and ground baiting (by hand from an all-terrain vehicle or car) of oral baits allowed the pattern of potential savings to be observed when bait costs

($\$/\text{bait}$), bait densities ($\#/\text{km}^2$), baited areas (km^2), and seropositive conversion rates of animals were altered hypothetically. Repeated calculations for hundreds of combinations of these variable inputs produced a scalloped response surface that showed benefit–cost ratios ranging between <1.0 and 8.0 , depending upon assumed postoutbreak expenses for prophylaxis treatments. Preliminary results indicate that benefit–cost ratios increased as bait density and bait cost declined, but as seropositive conversion rates for raccoons increased; benefit–cost ratios became greater as the estimated costs (potential savings) of postexposure prophylaxis treatments of companion animals, livestock, and humans increased.

Damage Assessment Methods—Accurate estimation of crop damage by wildlife often requires labor-intensive sampling procedures. Variable area transect (VAT) sampling has been identified as a potential labor-saving alternative to quadrat sampling. In 2002, a study evaluating the VAT for estimating large-mammal damage to corn was completed. In this study, all damaged corn plants were fully enumerated in a field to assess accuracy of sampling by small quadrats 5 m long by one or two row widths, and by VAT sampling with searches from random starting points to the 3rd, 4th, 5th, and 6th damaged plant. Two widths for strip transects also were considered for VAT sampling: one and two crop rows. Two analytical formulas were considered for the VAT data. Thus, 18 estimates of damage were produced and compared for accuracy with the true damage level. Sampling and enumeration were carried out the same day, so that the damage level could not change between enumeration and sampling. Estimation from VAT sampling using the original formula showed promise as a low-labor assessment method by producing highly accurate estimates (<1.5 percent absolute relative bias) when strip transects of two row-widths were searched to the 4th or 5th damaged plant.





Optimization of Ordered Distance

Sampling—Ordered distance sampling is a point-to-object sampling method that can be labor-efficient for demanding field situations, including some situations for the estimation of animal damage to crops. Sampling takes place by placement of n random sampling points in the area of interest. The distance to the g^{th} nearest object of interest (damage point) is measured. An extensive simulation study was conducted to find the optimum number, g , of population members to be encountered from each random starting point in ordered distance sampling. Monte Carlo simulations covered 64 combinations of 4 spatial patterns, 4 densities, and 4 sample sizes. Values of g from 1 to 10 were considered for each case. Relative root mean squared error (RRMSE) and relative bias were calculated for each level of g , with RRMSE used as the primary assessment criterion for finding the optimum level of g . A nonparametric confidence interval was derived for the density estimate, and this was included in the simulations to gauge its performance.

Superior estimation properties were found for $g > 3$, but diminishing returns, relative to the potential for increased effort in the field, were found for $g > 5$. The simulations showed noticeable diminishing returns for more than 20 sampled points. The nonparametric confidence interval performed well for populations with random, aggregate or double-clumped spatial patterns but rarely came close to target coverage for populations that were regularly distributed. The nonparametric confidence interval presented here is recommended for general use.

Title: Induced Infertility: A Wildlife Management Tool

Goal: Develop and test economical and effective agents to control fertility in populations of pest mammals and birds.

This project attempts to develop infertility agents for several wildlife species that cause conflicts with humans, including rodents, feral hogs, Canada geese, and white-tailed deer. Results of this research may be used to develop alternative management tools.

Gonadotropin-Releasing Hormone (GnRH) Immunization of California Ground Squirrels for Population Management—California ground squirrels cause considerable damage in both agricultural and urban areas. Currently, poisoning is the most common method of controlling overabundant populations. However, lethal control measures are not legal in some parts of California. GnRH contraception is being evaluated as a control measure for use as an alternative to poisoning. GnRH is a hormone that controls reproduction in both males and females. Immunizing against GnRH causes the immune system to inactivate the hormone. With GnRH inactivated, both males and females are infertile. In other species of animals in which the vaccine has been tested, the contraceptive effect can last for more than 1 year with a single injection.

A study is being conducted by vector control personnel in one Western State in collaboration with NWRC and with assistance from other Federal, State, county, and city personnel. Beginning in 2001, squirrels were trapped in a park where their high numbers are in conflict with human use. Since 2001, more than 175 squirrels have been trapped and injected

with the GnRH vaccine. None of the ground squirrels treated in 2001 and retrapped in spring 2002 was reproductively active. Additional measures of effectiveness of the treatment will include a visual population index based on juvenile and adult squirrel counts at the treated and control sites. The relative numbers of young per adult also will be used as a measure of contraceptive effect.

GnRH Contraception of Feral Hogs—The population of feral swine in the United States now exceeds 2 million animals, and at least 26 States have feral swine populations. Endemic in most of these populations are the diseases pseudorabies and brucellosis. With the near eradication of both these diseases in domestic swine, their presence in feral swine places at risk the local domestic populations. Many of these feral swine populations also cause extensive habitat destruction. An efficacious immunocontraceptive vaccine for feral swine would be a valuable tool for disease management of pseudorabies and brucellosis and in minimizing habitat degradation.

NWRC, APHIS' Veterinary Services, and cooperators at The Pennsylvania State University have begun research to develop contraception techniques as a tool to manage feral swine. A study with GnRH immunocontraceptive was conducted at Penn State with 50 domestic female pigs, as a model for the feral pig. The study compared contraception effectiveness among 5 groups of 10 animals each: a



control group, 2 groups injected with 2 dose levels of a single-shot vaccine, a group injected with a 2-shot vaccine, and a group provided GnRH orally. Initial estrus data indicate that all three injected treatment doses shut down estrus in the 5-month-old domestic pig as measured by lack of interest from the male breeder. Oral delivery was less effective in reducing estrus than injected delivery.

As a result of the success of the GnRH contraception tests with the domestic hogs at Penn State, 40 feral hogs (20 of each sex) were trapped in Trenton, FL, and injected with the single-dose immunocontraceptive vaccine. The feral hogs will be allowed to breed and will be kept confined until December 2002 to determine the contraceptive effect of the GnRH vaccine in the wild species. NWRC is also attempting to develop a more effective oral delivery system for the GnRH vaccine to make the contraceptive vaccine more practical for feral pig control.

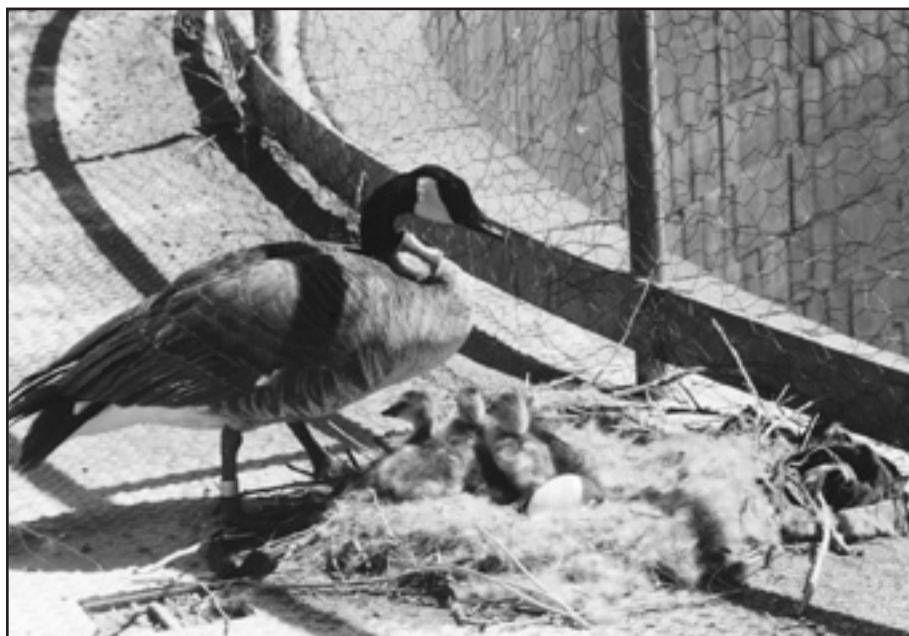
Title: Development of an Avian Infertility Tool for Application in Goose Management

Goal: Test the effectiveness and develop for use the contraceptive nicarbazin for reproductive control of geese.

Canada geese damage crops and deface property with their feces. In addition, they can pose health risks when feces contaminate urban environments. In recent years, resident goose populations have been growing. In such situations, it often is neither practical nor desirable to control resident goose populations by hunting. This project is investigating contraception as a nonlethal alternative to manage resident goose populations.

Nicarbazin as a Contraceptive To Reduce Canada Goose Populations—Nicarbazin traditionally has been used as a coccidiostat in the poultry industry but is showing promise as an oral contraceptive for geese. In the springs of 2001 and 2002, nicarbazin was coated onto cracked corn and fed to two goose populations near Fort Collins, CO. Baiting occurred daily at loafing sites and within some nesting territories. Field crews checked periodically for eggs and hatching and collected any eggs that did not hatch for analysis.

Baiting occurred over a period of 32 to 48 days in 2001, and egg hatchability was reduced by 20 percent and 43 percent at



the two treated study sites. In 2002, baiting occurred over a period of 33 days, and hatchability was reduced by 33 percent at both sites. Many of the geese at the sites did not feed regularly at the bait stations. For those that did feed regularly, reduction

in hatchability of eggs was much higher (80–100 percent). These studies show that while nicarbazin can be very effective in reducing the percentage of eggs that hatch from treated birds, getting the birds to eat the bait may be difficult.

Title: Development and Evaluation of Rodent Damage Management Methods, With Emphasis on Repellants, Barriers, and Attractants

Goal: Develop new and improved repellent and barrier strategies for damage caused by voles, pocket gophers, rats, and ground squirrels to agricultural crops and property. Develop rodent-detection methods and attractants to enhance effectiveness of existing tools, including rodenticides.



Many small rodent species cause substantial damage to grains, forage crops, reforestation areas, livestock feeds, property, and other resources. Researchers in this project are attempting to find new or improved approaches to reduce rodent damage. These studies include evaluations of repellants, barriers, frightening devices, biological control, and cultural methods.

Rodenticides and traps are still heavily relied upon for the control of rodent populations, and researchers also are providing data to maintain, or obtain new, registrations on rodenticides.

Odor Lures for Trapping Rodents—

Trapping success of wild rodents depends

upon several factors, e.g., population density, trap location, food availability, trap neophobia, and other factors. For commensal brown rats, carbon disulfide has been found an attractive agent that can be used to improve rodent bait acceptance. However, the degree to which this natural product (found in low [10 p/m] levels in expired breath of rats) is capable of attracting brown rats to live traps is unknown. Other food-odor extract lures (anise, sweet corn, apple, black walnut) have been commercially produced and marketed to improve rodent trapping efficacy. These five odors were evaluated for their potential in improving rat trapping success and were compared to

a deionized water control, using live traps with nine captive colonies of small groups of laboratory brown rats.

With two 3-hour trapping sessions per day over 5 days, 25 of the 27 animals (93 percent) were captured at least once with the anise oil lure. Carbon disulfide odor lure traps captured 22 of the 27 animals at least once. Other odor lures tested were no better than the water (control) traps, capturing on average 19 of the 27 animals. Traps treated with the carbon disulfide lure captured 12 of 12 female rats but only 10 of 15 male rats. This finding was consistent with previous studies showing that carbon disulfide attractant effects on bait acceptance were stronger for female rats than male. Sweet corn lure also captured a higher proportion of females (11 of 12) than males (10 of 15).

In terms of recapture rates, disproportionately more females were captured multiple times with the carbon disulfide lure, and disproportionately more males were captured multiple times with the black walnut lure. None of the other lures produced recapture rates that were relatively disproportionate for each gender.

The results of this study indicate that it is feasible to attract brown rats to live traps with natural product lures, possibly improving trapping efficacy, and to obtain proportionately more animals of one gender with selected odor lures. The ability to attract proportionately more females could be important, for example, in the case of

delivery of a female fertility control agent in the trap's bait.

Raptor Use of Artificial Perches at Prairie Dog Colonies—The expansion of prairie dog colonies in suburban settings causes many problems for homeowners. Prairie dogs also are an important part of the prairie ecosystem, and many persons like to see them on public lands. In some cases, city and county employees have erected artificial perches on public, open space lands and natural areas to attract raptors (birds of prey, such as hawks and owls) to help limit the expansion of prairie dog colonies into suburban housing areas. NWRC scientists and CSU students assessed the use of artificial perches by raptors. Perches were watched during 75 observation periods in fall 2001 and 2002 spring.

Raptors were observed during 63 percent of those observation periods. In 51 percent of the cases, raptors were observed flying, and in 62 percent, perching. Occasionally, both events occurred in the same observation period. There was little seasonal variation in perch use.

To determine what the raptors were feeding on, raptor casts (fecal pellets) were collected from below the artificial perches and dissected to identify prey fur, feathers, and bones. The main prey, in declining order of occurrence in the casts, were voles/field mice, prairie dogs, rabbits, deer mice, birds, insects, reptiles, and amphibians. There were only small differences between seasons. It is clear that the artificial perches are being used by raptors and that the raptors are consuming prairie dogs as a substantial part of their diet.

Survival of Pen-Reared Pheasants Related to Vole Control Efforts—In 1996 a study was conducted in California to evaluate the risk to free-ranging ring-necked pheasants from broadcasting a 2-percent zinc phosphide grain bait to control voles in alfalfa. The study showed minimal risk to pheasants, which did not use alfalfa areas after the alfalfa was cut. However, during the study, differential mortality was found between pen-reared and wild pheasants. In 2002, a study was conducted in Weld County, CO, by NWRC personnel to

investigate the rate and causes of mortality for pen-reared pheasants.

Twenty-four pen-reared ring-necked pheasant were radio-collared and released in agricultural areas on private property by a hunting club for hunting. Twelve pheasants were released at a site in late March a few hours prior to a hunt, and 12 were released along a river 2 days prior to a hunt. The former practice is used in the Plains States including Colorado, and the latter practice is used in California; both practices are used in both States by private hunt clubs to maximize the harvest success while keeping the hunts as natural as possible.

Locations of pheasants were determined from radiotelemetry signals. Sightings confirmed pheasant locations and causes of mortality for dead birds were confirmed by sightings. Following the hunts, activities of surviving pen-reared pheasants were monitored to determine their survival, habitat use, behavior, and effects of farming practices on mortality by predators. Of the 12 pheasants released at the site just before a hunt, all were killed by hunters or predators (mostly owls) within 7 days. Of the 12 released along a river 2 days prior to a hunt, none were killed by hunters; most were killed by owls and 2 survived for 10 weeks following release.

Survival was probably higher for the pheasants released 2 days before a hunt because as they became familiar with their habitat, they moved into agricultural fields. They moved first into alfalfa fields and then into the better cover afforded by wheat fields. This research should be beneficial to farmers, ranchers, and private hunting clubs that release pen-reared pheasants for private hunting and to State game and fish agencies in their management of both wild and pen-reared pheasants.



Title: Development of Chemical Based Tools for Wildlife Damage Management

Goal: Develop chemical based techniques and tools that fulfill the research needs of WS.



Analytical chemistry forms the foundation of much of the research conducted under this project. Project scientists have experience in related scientific disciplines, e.g., metabolism chemistry, environmental fate, chemical synthesis, toxicology, chemical ecology, and chemical formulation. Project

personnel also initiate and/or collaborate on a wide variety of studies that contribute to development of wildlife management tools by other NWRC scientists.

Development of Attractant Delivery Devices—In 2002, project research has

focused on novel delivery devices for synthetically derived coyote attractants. Previous research employing chemical analyses of biologically based attractants led to the development of seven new synthetic attractants. Bioassays demonstrated that these simple attractants produced a variety of behaviors in captive coyotes, such as pulling, digging and rolling. Project scientists are currently testing delivery devices that exploit these coyote behaviors to achieve improved wildlife damage management goals. Several prototype molds have been manufactured that produce polymer-based lures that fit directly onto M-44 devices.

Risk Assessment for an Acetaminophen Mouse-Baiting Program To Control the Brown Tree Snake (BTS) on Guam—

NWRC chemists conducted residue analyses, storage stability, and field stability studies on acetaminophen mouse baits and acetaminophen poisoned snake carcasses. These residue, stability, and degradation data were used to determine primary and secondary hazards to nontarget wildlife feeding on the acetaminophen mouse baits and acetaminophen-poisoned snake carcasses. Data from behavioral studies conducted by NWRC researchers at field stations and on Guam were used to develop a more detailed risk characterization for species associated with significant primary or secondary hazards. The risk assessment indicates that for most nontarget species, the risks associated with an acetaminophen baiting program are acceptable and justified with respect to the potential ecological, agricultural, and economic benefits of reducing BTS populations on Guam.

Title: Field Evaluation of Chemical Methods for BTS Management

Goal: Develop techniques to help control BTSs on Guam and prevent their dispersal from that island.

Background—The BTS, an accidentally introduced species to the island of Guam, has decimated that island's native fauna and poses a similar threat to other Pacific island ecosystems. NWRC scientists are field testing chemical methods to control the BTS, including toxicants, attractants, repellants, fumigants and reproductive inhibitors. The eventual goal is to use these methods in an integrated program to control the BTS on Guam, prevent its dispersal from Guam, and reduce or help control snake populations, when necessary, in other island situations. The Center's goals are to field-test these methods for efficacy and make them available for use by a variety of individuals and organizations, including WS, the Department of Defense, the Government of Guam, natural resource managers, military personnel, and others.

Aerial Delivery of Baits to BTSs—Current management methods for BTSs do not efficiently depopulate large, remote areas—a prerequisite for the effective reintroduction of endangered species. Bait stations containing dead neonatal mice implanted with acetaminophen effectively remove snakes, but their use is limited to accessible areas. NWRC scientists developed and tested aerial delivery methods to distribute baits in forest canopy on Guam. Mouse baits with implanted miniature radio transmitters were dropped over inaccessible, dense forest canopy. Bait uptake by snakes and other species was recorded, and morphology and movements of snakes that consumed baits were measured.

Bait take by snakes was high (63 percent) using parachuted baits that were designed to entangle in forest canopy, and snakes moved between 1 and 70 m after consuming baits before dying. Snakes that consumed baits were of similar size, weight, and body condition as snakes captured in traps on the drop areas. This study also showed that implanting transmitters in carcass baits is a useful method for monitoring postbaiting BTS movements.

Evaluation of Snap Traps as a Monitoring Technique for BTSs—Rat snap traps baited with dead mice were evaluated on Guam as a potential inexpensive technique for capturing BTSs. Snap traps were enclosed with wire mesh, except for the trigger end, which was open to direct the approach of the snake to the mouse-baited trigger. The efficacy of snap traps was compared to the capture of snakes in live

snake traps using a live mouse lure and to the take of dead mice from bait stations made of plastic pipe. Testing was conducted on the forest perimeter with randomized placement of the test devices hung about 1.5 m high in vegetation at 20-m intervals.

Snake capture was 62 percent with the live traps (85 percent when multiple captures were included) and 38 percent with the snap traps. Bait-take from the bait stations was 63 percent. While these snap-trap results are encouraging, additional developmental work would be needed to increase their efficacy for use as another BTS control method.

Evaluation of BTS Baiting in a Snake Live-Trapped Area—NWRC and Guam Division of Aquatic and Wildlife Resources investigators evaluated the consumption (bait-take) of untreated young dead mice



by BTSs in a previously trapped area. This area serves as a site for finding improved management tools for recovery of endangered species, such as the Guam rail. Twenty-five bait stations were placed inside a 24-ha limestone forest area surrounded by a snake fence barrier. Eight of the 25 mice contained radio transmitters. Extensive snake removal by live-trapping has been conducted in this area. In the preceding 6 months before bait-take was evaluated, snake capture was 0–5 snakes/week (0 percent to 0.5 percent snake captures per week) from 140 live traps on 14 transects. In contrast, dead mouse bait-take was 60 percent after a single 2-day exposure, and four of the eight mice containing radios were consumed by snakes. These data indicate that baiting with dead mice is highly effective in areas where snake trap capture has stagnated after long trapping periods.

Field Evaluation of Caffeine as an Oral Toxicant for BTSs—In laboratory evaluations, caffeine and acetaminophen have shown similar toxicity profiles in BTSs. The efficacy of acetaminophen has been demonstrated in previous field trials; therefore, a field evaluation was conducted to determine the efficacy of caffeine as a BTS toxicant. In the field evaluation, 80-mg caffeine tablets were inserted in young dead mice and the mice were placed in PVC bait delivery stations hung about 1.5 m high in vegetation at 20-m intervals on the perimeter of forest plots. Efficacy was evaluated as the presence or absence of mice recorded every 2 days from the bait stations during the pretreatment, treatment, and posttreatment baiting periods on the control and treated plots.



This study indicated that snake populations were reduced about 79 percent in the treated plots over a 14-day treatment period. These results are similar to results previously obtained with acetaminophen. In the unlikely event that acetaminophen cannot be used for operational control caffeine may be a suitable substitute.

Development of Repellants for Driving BTSs From Cargo—Investigators previously identified essential oils and constituent compounds that are potent snake irritants that can be used as repellants. Previous tests indicated that oils such as cinnamon oil, clove oil, and eucalyptus oil containing the primary compounds cinnamaldehyde, eugenol, and cineole were all highly active as repellants when delivered as aerosols. Current testing indicates that these compounds can be delivered as vapors by simple heating, and that this process increases the

penetrating potential of the repellant into enclosed spaces such as is typical of cargo containers. This fumigation is sufficient to drive snakes from the simulated cargo containers and may prove useful in the operational removal of snakes from cargo. The NWRC is currently preparing EPA labels for operational use.

Research on More Attractive Mouse Baits—Previous studies have indicated that dead mice are as effective a snake lure as live mice, and mouse carrion has proven effective in delivering the BTS toxicant acetaminophen. Over the years other baits have been tried as snake attractants (e.g., eggs, chicken carcasses) with little success. Recent studies indicate that beef is moderately effective as a lure and bait but is only about 40 percent as effective as mouse carrion. This inefficiency may be tolerable because of the potential to produce large numbers of baits from a single cow carcass

and a lower per-unit cost relative to mouse carrion. Additionally, cubes of beef baits would be logistically easier to employ in the field. Such cost and logistical efficiencies will be important for large area operational control of the BTS. Research is needed to determine if the rate of bait acceptance can be improved.

NWRC previously identified the key elements that make mouse carrion attractive to BTSs. The attractive odors are produced by the decomposition of mouse skin by the bacterium *Enterobacter agglomerans*. Through cell tissue culture techniques, NWRC has produced mouse skin and is determining whether this dissociated tissue is attractive to snakes. If so, the cultured cells may be useful as

a dilute additive to beef baits that would increase the attractiveness of that lure/bait system.

Improved Success in Captive Breeding the BTS Enables Testing of Reproductive Inhibitors

—Reproductive inhibition is being investigated as a means of controlling the BTS on Guam. A colony of BTSs was established at NWRC for the purposes of developing a method for captive breeding and testing reproductive inhibitors. Breeding was first attempted in 2001 and was successful: three of eight females kept under one of two experimental temperature regimes each produced a clutch of eggs.

In 2002, success was substantially improved by keeping all 15 females in the colony under the successful 2001 temperature regime. Fourteen of the 15

females became either gravid or had egg-sized follicles in the ovaries. At least 108 eggs or egg-sized follicles were detected by palpation, with individual clutch sizes ranging from 3 to 9. Reproduction by females in the laboratory was unequivocally initiated by a period of cool temperatures. The extent of the drop and duration do not seem to be critically important. Females appeared to respond reproductively to the rise in temperature and initiated the process in near synchrony. However, because of a failure of female snakes to mate with males, most follicles and eggs were reabsorbed. Nonetheless, these results show that it is possible to effectively bring snakes into reproductive condition to test potential reproductive inhibitors under controlled laboratory conditions.

WILDLIFE DISEASES RESEARCH PROGRAM

Title: Waterfowl as Disease, Parasite, and Noxious Weed Reservoirs in Urban and Agricultural Landscapes

Goal: *Understand and develop management recommendations related to the contribution and impact of Canada geese as vectors for disease, parasites, and noxious weeds on human health and safety in urban landscapes and on animal health in agricultural landscapes.*



Despite considerable demand for information on the impact of waterfowl—specifically geese—on human health and safety, little is known on this issue. This project is gathering information on the potential for geese to act as vectors for pathogens to humans in urban landscapes.

Evaluation of Canada Goose Disease Transmission—Nonmigratory populations of Canada geese have risen dramatically over the past 30 years. The increasing use of public landscaped areas by geese and the increase in fecal contamination of those areas has raised concern that geese may contribute to human health risks. Yet few data are available on this issue. To better understand the role of Canada geese in human exposure to bacterial pathogens, a national survey for bacteria found in goose feces was conducted over 1 year in five States: California, New York, Oregon, Washington, and Wisconsin. The

bacterium, *Escherichia coli*, is a common one found in the intestines of animals, and most forms are nonpathogenic. However, virulent strains exist. Common virulence factors associated with pathogenesis were screened in fresh goose feces collected from urban landscapes.

The percentage of feces containing *E. coli* varied with time of year. The highest prevalence for *E. coli* occurred during the summer months (60–95 percent). Prevalence during the winter months was lower (2–20 percent). The virulence factors SLT-I, SLT-II, *eae*, *hly*-A, LT, STb, CNF1, and CNF2 were not found in any of the May–June samples. However, two other virulence factors were isolated. K1 capsular antigen occurred in 3.6 percent of fecal samples from California and 3.8 percent of samples from Wisconsin. The gene coding for enteric STa toxin occurred in 2.0 percent and 3.9 percent of fecal samples from New York and Washington, respectively. No virulence factors were isolated from Oregon samples.

Biologists also screened for other bacteria. *Campylobacter* is the most common causative agent for enteric illness.

Campylobacter species were isolated in fecal samples from California (15 percent [spring] and 58 percent [fall]), New York (12 percent [spring] and 25 percent [fall]), Washington (8 percent [spring]), and Wisconsin (20 percent [spring]). *Listeria monocytogenes* is less frequently involved in human illness, but when present it is a serious pathogen. *L. monocytogenes* was detected in spring goose fecal samples: California (4 percent), New York (8–10 percent), Washington (4–8 percent), and Wisconsin (8–12 percent). These results are not an indication of absolute human health risk, rather they are important in establishing that potential links between environmental contamination from goose feces and human health risks bears closer scrutiny. Further research will focus on the nature of the goose bacterial pathotypes and eventually help in formulating goose management strategies.



Title: Controlling Wildlife Vectors of Bovine Tuberculosis and Rabies

Goal: To study the ecology of wildlife diseases, assess the risk of disease transmission among wildlife, domestic animals, and humans, and develop methods that reduce or eliminate such transmission

One human–wildlife conflict that has received increasing attention is the potential transmission of diseases among wildlife, livestock, and humans in the United States. Diseases such as rabies, West Nile virus, hantavirus, and Lyme disease have resulted in zoonoses, while others such as bovine tuberculosis (TB), pseudorabies, and foot-and-mouth disease have the potential to negatively affect livestock.

In 2000, the Secretary of Agriculture enacted Declarations of Emergency for bovine TB and rabies, citing threats to livestock and human health and safety. In an effort to assist in the control of TB and rabies, NWRC began research in 2002 related to the potential wildlife reservoirs and the transmission of bovine TB and rabies.

Deer–cattle interactions in Michigan: Implications for Bovine TB—

Mycobacterium bovis infection in wildlife and livestock is initiated by the inhalation or ingestion of infectious particles. Interactions between white-tailed deer and cattle may be an avenue for the interspecific transmission of bovine TB. NWRC is (1) documenting interactions between white-tailed deer and cattle in the northeastern portion of Michigan's lower peninsula, (2) evaluating differences in the characteristics of interactions between deer and cattle in areas with high TB prevalence in deer and areas with low TB prevalence in deer,

(3) determining if white-tailed deer visit areas commonly used by cattle when the cattle are absent, and (4) documenting interactions between other wildlife species and cattle in the northeastern portion of Michigan's lower peninsula.

To date, no direct deer–cattle interactions (i.e., individual deer and cattle within 5 m of each other) have been observed on any of several study sites in Michigan. There is no evidence of deer approaching cattle closer than 20 m, nor is there evidence that deer are entering holding pens or pastures containing cattle. All food sources used by deer have been located away from the cattle. However, on two farms deer have been observed feeding out of the open end of silage bags on several separate occasions.



PROGRAM SUPPORT

Registration Highlights

In conjunction with staff from the APHIS headquarters in Riverdale, MD, the NWRC Registration Unit is responsible for coordinating the development of data required for maintaining or modifying authorized uses of APHIS vertebrate control products to meet the varied demands involved in protecting agriculture, endangered species, and public health. To meet this responsibility, the Registration Unit works closely with scientists to ensure that research results will be acceptable for regulatory purposes and that study designs meet EPA and FDA regulatory guidelines. In addition, the Registration Unit responds to requests from field personnel for new products or changes to existing products that will improve their ability to manage problem wildlife. Technical assistance and information are provided to State WS personnel and Federal and State agricultural and conservation agencies, as well as other nongovernment groups and individuals.

Registration Status of APHIS Vertebrate

Pesticides—APHIS vertebrate control agents are typically products that have limited demand compared to other pesticides such as herbicides and insecticides. Because of the high cost of getting them registered, coupled with this low demand curve, private companies are reluctant to register these agents. But because they are important tools for managing wildlife problems, APHIS supports their registration. APHIS currently holds registrations for eight active ingredients used in vertebrate control products. These active ingredients are formulated into 19 unique Federal registrations. Currently registered products include an avicide (DRC-1339), an avian repellent (methiocarb), two rodenticides (strychnine and zinc phosphide), a fumigant (two sizes of gas cartridges that

contains carbon and sodium nitrate), and two predacides (compound 1080, used in the Livestock Protection Collar [LPC] and sodium cyanide, used in the M-44).

DRC-1339: DRC-1339 is the only currently registered avicide in the United States. APHIS maintains the registrations for five products containing DRC-1339. These products are very specific in terms of what species can be targeted and what use sites are authorized. The five products target species like blackbirds and starlings, pigeons, gulls, and corvids (crows, ravens, and magpies). Use sites include feedlots and staging areas, structures, landfills, livestock birthing areas, and habitats of threatened or endangered species. In addition, APHIS either applied for or received approval for four State-specific labels. These State registrations are primarily for corvids to protect human health or apple and pecan orchards from damage.

Mesuro: APHIS holds the only registration for using MesuroTM (methiocarb) as an avian repellent. The APHIS product is used as a aversive conditioning agent to train crows and ravens not to eat the eggs of threatened or endangered species. This work is done prior to the beginning of the protected species' nesting season. Hard-boiled chicken or quail eggs are treated with methiocarb, and the eggs are fed to ravens in nesting areas of threatened and endangered species. Upon ingesting the egg, the bird gets sick and learns to avoid other eggs.

Strychnine and Zinc Phosphide:

NWRC staff members coordinate two consortia, the Strychnine Consortium and the Zinc Phosphide Consortium. These consortia were established to help meet the EPA reregistration requirements for these compounds. With the exception of changes to the required personal protection equipment for handlers, all of the reregistration requirements have

been met for strychnine. The registration eligibility decision for zinc phosphide was issued in August 1998, and EPA is currently evaluating all of the data submitted in response to that document. APHIS maintains the registrations for four strychnine products, all of which are for belowground application to control pocket gophers, and three zinc phosphide products for controlling field rodents. APHIS does not register any rodenticide products for commensal rodents.

Gas Cartridge: APHIS maintains the registration for two gas cartridges used for fumigating the burrows of rodents and predators. No registration actions occurred for these products during fiscal year (FY) 2002.

Compound 1080: APHIS maintains the registration for two formulas for compound 1080. The LPC is used to protect goats and sheep from coyotes. It contains two small rubber bladders filled with small amounts of compound 1080 and is attached to the neck of a young sheep or goat. Compound 1080 is released from the bladders only when punctured by the teeth of a coyote biting the neck of the animal. The other compound 1080 registration is a manufacturing use product used to make the LPC. No registration actions occurred for these products during FY 2002.

M-44: The M-44 is used to protect livestock and endangered species from predation by canines. During the last year, two significant actions occurred with the M-44 registration. APHIS submitted a registration application to the State of Texas that would allow the use of the M-44 for coyote control to protect wildlife species. An Experimental Use Permit was requested from EPA to allow WS scientists to assess the effectiveness of using the M-44 for this purpose. This study should begin in early 2003, once EPA approval is obtained. If the study shows advantages to using the



M-44 over current predator management methods and EPA approves the Texas State registration, the M-44 could become a valuable tool in WS wildlife conservation efforts.

Acetaminophen: During FY 2002, APHIS submitted a Section 3 (Federal) registration request to EPA for the use of acetaminophen to control the BTS on Guam. Once approved, this registration will allow the use of specially designed bait stations, baited with acetaminophen-treated dead mice, to control snakes in and around shipping terminals and in areas of native species conservation. This submission included information designed to address more than 50 individual data requirements, 9 of which directly addressed hazards to nontarget species. In addition, APHIS received an Emergency Use Permit from EPA to allow aerial baiting with acetaminophen-treated dead mice. Aerial baiting will be useful for baiting in areas where installing and maintaining bait stations is either impractical or dangerous, such as cliff lines.

FDA Wildlife Drug Authorizations— APHIS has five Investigational New Animal Drug (INAD) authorizations with the FDA that allow interstate transport of the compounds for experimental purposes. Two

products are immobilizing agents; three are contraceptives. All of these products are for use by USDA personnel or persons under their direct supervision.

The immobilizing agent alpha-chloralose is authorized for use to capture waterfowl, coots, and ravens. During FY 2002, FDA authorized the use of tableted alpha-chloralose. Since this new form does not involve prior mixing or the use of syringes to treat bait materials, it is a safe alternative for field use. Propiopromazine hydrochloride is used in the tranquilizer trap device for sedating animals captured in leghold traps. This compound significantly reduces the amount of potential damage the trap does to the leg of an animal prior to being released.

Two of the INADs are for immunocontraceptive vaccines containing GnRH and porcine zona pellucida (PZP). Research efforts are underway to develop a dart-delivered, single-shot vaccine that would be effective for multiple years. The current focus of registration activities on PZP and GnRH involves locating a private company to enter into a partnership to develop and market the vaccines. The fifth INAD is for an avian oral contraceptive, DiazaCon (20,25-diazacholesterol).

Regulatory Assistance Provided to Federal, State, and Nongovernment

Organizations—WS program personnel or other Government and nongovernment cooperators frequently contact the NWRC Registration Unit for information when preparing Environmental Assessments, Environmental Impact Statements, and Section 7 consultations with the FWS. NWRC is the primary supplier of these data to the WS program and its cooperators. Often responses to these inquiries entail preparing unique summaries and interpretations of NWRC research. For example, NWRC personnel are providing technical assistance to a consortium of State, Federal, and nongovernmental organizations in Hawaii by developing a registration package and risk assessment for registering diphacinone as an aerially delivered anticoagulant rodenticide to control rats in conservation areas. These efforts are designed to lower rat populations and reduce rat predation on endemic birds.

Information Transfer Activities—With the cooperation of headquarters staff, the Registration Unit expanded the NWRC Web site to include sample copies of the most current APHIS vertebrate pesticide labels as well as WS "Tech Notes," which provide information on the proper use of APHIS pesticide products. Current information on NWRC's investigation of wildlife immobilizing and contraceptive agents can be found at <http://www.aphis.usda.gov/ws/nwrc/RegUnit.htm>.

In cooperation with a retired NWRC scientist, the Registration Unit continues to develop a fully searchable, electronic toxicology database. This database contains data for 6,800 chemicals that were screened for toxicological and repellency properties at the Denver Wildlife Research Center between 1960 and 1987. This database provides rapid access to the results of more than 23,000 individual toxicity tests conducted with up to 127 species (7 plants, 84 birds, 32 mammals, and 1 amphibian). NWRC expects to publish the contents of this database as well as make it available in a searchable form on the NWRC Web site.

PROVIDING WILDLIFE SERVICES

Goal: Provide high-quality wildlife damage-management services for our customers that result in the protection of agriculture, wildlife and other natural resources, property, and human health and safety.

NATIONAL SUPPORT

Bird—Aircraft Strike Identification—On May 8, 2002, a private jet struck a flock of gulls on takeoff from an Ohio airport. The pilot aborted takeoff due to strike damage to both engines, including an uncontained engine failure (parts came out of the engine). The strike was reported to the National Wildlife Strike Database manager at the NWRC Sandusky field station, but the gulls had not been identified to species. A biologist visited the airport soon after the strike and recovered the remains of 12 gulls involved in the strike. They were identified as herring and ring-billed gulls.

Wisconsin Wildlife Sanctuary Consultancy—An NWRC scientist from Fort Collins, CO, has been working with a wildlife sanctuary in Wisconsin between 2000 and 2002 to develop methods to reduce the Canada goose population that uses the area and to mitigate associated damage. Research conducted at the site has included studies on reproductive inhibition, hazing techniques, and resident goose biology/ecology. Results of the NWRC studies are now being used by the mayor of the local city in a grant application for \$1.75 million. These funds are to be used to repair the damage to surface water and shoreline habitat that has been caused by geese over the past 25 years.

Wood Storks in Mississippi—There is increasing concern in eastern Mississippi and western Alabama that wood storks may potentially lessen catfish production at aquaculture facilities. In July 2002, three NWRC scientists assisted biologists from the FWS and the University of Georgia's Savannah River Ecology Lab with capturing, banding, and collecting feathers and other tissue samples from wood storks at the Noxubee National Wildlife Refuge in east-central Mississippi. These activities are part of an FWS study to determine whether the storks in eastern Mississippi are from an endangered population that breeds in Florida or from a second, nonendangered population that breeds in Mexico and Central America. Additionally, NWRC biologists will begin studying both stork food habits and their level of use of catfish facilities.

North American Breeding Bird Survey—The North American Breeding Bird Survey, begun in 1966, consists of about 3,000 24.5-mile routes that are surveyed by ornithologists each June to document population trends of birds throughout the United States and southern Canada. Using a standardized format, trained observers record the total number of birds seen or heard, by species. Data generated by the

North American Breeding Bird Survey help researchers understand not only the basis for conflicts between certain bird species and humans but also the impacts of various management actions taken to resolve these conflicts. Two scientists from the NWRC Sandusky field station conducted North American Breeding Bird Survey routes in June 2002.

Implementation of Operational Population and Damage Monitoring for Feral Swine—In 2002, an NWRC researcher, working in a partnership with WS Florida State office and the Florida Department of Environmental Protection, oversaw the design and implementation of a passive tracking plot system for monitoring feral swine populations in three Florida State parks. This monitoring program will assess the distribution and abundance of swine, evaluate their damage from an economic standpoint, optimize and assess the efficacy of swine removal efforts, and evaluate reinvasion after control. Students from local universities are being included in the damage assessment efforts as part of their coursework.

Rodent Monitoring Methods for Native Habitats and Agriculture in California—In 2002, an NWRC researcher received a collaborative grant with a researcher at the

INTERNATIONAL COOPERATION

University of California–Davis to develop and test rodent index methods. Muskrats, voles, and black rats cause extensive damage to agriculture, native species and structures in California. The primary focus of this cooperative effort is directed at meadow voles because they can be a highly destructive species in many agricultural settings. The rats kill native birds in some riparian habitats, and the muskrats are an exotic species in the river systems where they are the cause of bank erosion in pasture lands.



New Zealand Collaboration on Detecting and Monitoring Brushtail Possum Populations To Control Bovine TB

TB—Besides causing significant damage, brushtail possums, an introduced species in New Zealand, are the principal maintenance host of TB there and are the underlying cause of TB persistence in livestock and in spillover hosts, such as ferrets and deer. In 2002, an NWRC researcher was requested by a scientists with the New Zealand Manaaki Whenua Landcare Research to develop methods to index possum populations and detect remnant patches of high-density possums in the landscape. The Landcare scientist was awarded a sabbatical at NWRC between May and September 2002 from his agency to continue this collaboration. The findings from this joint effort will be of national importance to New Zealand and will likely benefit efforts to address wildlife diseases in the United States.

NWRC–Australian Field Evaluation of Mark–Recapture Population Estimation Methods

Methods—An NWRC researcher completed a joint collaboration in 2002 with a Commonwealth Scientific and Industrial Research Organization (CSIRO) Australian government researcher and a researcher at the Queensland University of Technology that examined mark–recapture population estimation techniques. Mark–recapture is one of the most prominent methods in use for collecting data to estimate animal abundance. The researchers found that even under seemingly ideal circumstances, mark–recapture estimation can be highly sensitive to deviations from underlying

assumptions, and those deviations may be difficult for the investigator to detect or recognize.

Mongoose Rabies Vaccination Project Planning in Puerto Rico—In May 2002, three members of WS rabies management teams, including the WS Florida State Director, a biologist from NWRC, and the director of the Florida oral rabies vaccination (ORV) program, conducted multiagency organizational meetings to develop groundwork for a program of ORV for mongooses in Puerto Rico. The meetings included staff and officials from the Puerto Rico Department of Agriculture, the Puerto Rico Department of Health, FWS/Caribbean National Forest, APHIS Veterinary Services, the DoD, and the University of Puerto Rico. The meetings identified needed research directions and resources and strategies needed to implement an ORV program.

Monitoring Black Rats and Mongooses in Puerto Rico—NWRC is working with a University of California researcher and graduate student, the WS Florida State office, and the USDA Forest Service to devise and test monitoring methods for black rats and mongooses in Puerto Rican habitats and to help understand their biology, including home range sizes and invasion rates into low-density areas. Black rats and mongooses are both potential predators of the critically endangered Puerto Rican parrot. Strategies for managing these animals—either for parrot protection or for rabies control—are needed.

VALUING AND INVESTING IN PEOPLE

WS Safety and Health Unit of the Year

Award—NWRC's Mississippi field station was the recipient of the 2002 WS Safety and Health Unit of the Year award. Mr. Paul B. Fioranelli, a wildlife technician at the station, received the 2001 WS Safety and Health Employee of the Year award as well. Field station staff participated in numerous safety awareness classes and instituted precautions to prevent injuries during use of firearms and ammunition, motor vehicles, boats, and other specialized equipment commonly used by the staff. During 2001, field station staff drove about 35,000 miles and spent 50 hours in boats at night capturing birds and conducting research without any accidents.

WS World Trade Center Disaster

Response Team Award—Two Sandusky field station scientists were part of a five-person WS group that received the Secretary of Agriculture's Honor Award at ceremonies in Washington, DC, and Riverdale, MD, on July 8–9, 2002. The award was given to the WS World Trade Center Disaster Response Team for assisting with World Trade Center recovery efforts at the Staten Island Landfill by dispersing birds that were interfering with identification of human remains and evidence documentation. Group leader for the award was the New York State director for WS. Emergency assistance was requested from the WS program by the New York City Police Department, the Port Authority of New York and New Jersey, and the Federal Bureau of Investigation. When the debris sifting efforts first began in September 2001, more than 2,500 gulls came to the site, disrupting workers and interfering with remains and potential evidence. The New York WS and NWRC biologists successfully implemented a harassment program using such tools

as pyrotechnics, lasers, Mylar™ flags, paint-ball guns, and dead gull effigies. WS biologists remained onsite for 9 months until the collection effort for evidence and human remains was completed.

NWRC Director Honored—NWRC Director Richard D. Curnow was recognized in April 2002 by the CSU Alumni Association as an outstanding alumnus in the field of natural resources. An Honor Alumnus/Alumna is a former student who, by distinguished career and service to the university, State, Nation, or world, has brought honor to CSU and to himself or herself. Curnow received his Ph.D. in wildlife biology from CSU in 1970 and has been NWRC director since 1994.

Jack H. Berryman Institute Awards—The Jack H. Berryman Institute, at Utah State University, annually recognizes significant achievement in wildlife damage management. In May 2002, several WS personnel were honored for their contributions. The Berryman Institute's Program Achievement Award went to WS' BTS program, both operations and research. WS biologists Richard A. Dolbeer and Sandra E. Wright and former WS employee Edward C. Cleary, a wildlife biologist now with the FAA, received the Institute's Research Award for their work to reduce the threat of wildlife collisions with aircraft. Michael Fall, a retired NWRC scientist, was honored with the Institute's Lifetime Achievement Award for his decades of research aimed at resolving wildlife damage. The Berryman Institute is a national organization that works to promote human–wildlife relationships and resolve human–wildlife conflicts through research, extension, and education programs.

2001 NWRC Publication Awards—NWRC Director Richard Curnow presented the 2001 Publications Awards to the NWRC

authors of the following publications: Jojola-Elverum, S. M.; J. A. Shivik; L. Clark. 2001. Importance of bacterial decomposition and carrion substrate to foraging brown treesnakes. *Journal of Chemical Ecology* 27:1315-1331. Savarie, P. J.; J. A. Shivik; G. C. White; J. C. Hurley; L. Clark. 2001. Use of acetaminophen for large-scale control of brown treesnakes. *Journal of Wildlife Management* 65(2):356-365. These publications are excellent examples of the quality of research being done by Center scientists to control the brown treesnake on Guam.

Arizona Tres Rios Project Award—Dale Nolte, NWRC Olympia, WA, field station leader, was recognized by the WS Arizona program for his contributions to the Tres Rios Demonstration Project in June 2002 during the Arizona State meeting. The Tres Rios project is restoring critical riparian and wetland habitats that were previously lost because of water resources development in the Phoenix metropolitan area.

Visiting Scientist—NWRC hosted David Ramsey as a visiting scientist during the summer of 2002. Ramsey has been a researcher for Manaaki Whenua Landcare Research in New Zealand for 7 years. Landcare Research is a Crown (Government) research institute specializing in environmental research, principally in the areas of land degradation, biodiversity, and wildlife pest management. Ramsey's primary areas of research have been in field experiments and quantitative theory related to controlling disease in wildlife populations. He was awarded a traveling fellowship (sabbatical) to work in collaboration with NWRC to develop a brush-tailed possum monitoring system capable of detecting and indexing relative abundance of patches with high-density possum populations in a landscape with potential to harbor TB.



APHIS Designated Agency Safety and Health Official Award—The National APHIS Safety and Health Council annually recognizes employees and program units for outstanding efforts in promoting a safe workplace within APHIS. The annual Designated Agency Safety and Health Official (DASHO) Award is selected by the APHIS Safety, Health, Environment and Security Branch for presentation to a regional, laboratory, or headquarters unit that has achieved noteworthy and proactive accomplishments to address safety and health issues during the year.

The DASHO Award for FY 2001 was presented to the WS Safety and Health Council on June 26, 2002, during the National APHIS Safety and Health Training Conference in Salt Lake City, UT. The WS Council was recognized for its efforts to help promote a safer working environment throughout the program and for assisting with the preparation and distribution of the WS Firearms Safety Training Manual. NWRC employees who currently serve on the WS Council include Steve Greiner (Fort Collins, CO) and Jeff Homan (Bismarck, ND).

NWRC Sabbatical in New Zealand and Australia—Lowell Miller spent the month of April 2002 in Lincoln, New Zealand, at Landcare Research and in Canberra, Australia, at CSIRO as part of a sabbatical program. The purpose of the trip was to share contraceptive technology between NWRC and the two research facilities. Miller gave three formal presentations during the visit and spent the majority of the time working with Landcare Research scientists in New Zealand. He also visited researchers at Lincoln University and in Wellington and Dunedin, NZ, who are involved in TB research on brush-tailed possum and red deer. New Zealand is interested in developing contraceptive vaccines to reduce populations of brush-tailed possums, which spread TB to deer.

INFORMATION AND COMMUNICATION

Goal: Collect and analyze internal and external information to monitor and enhance program effectiveness. Communicate internally and externally to accomplish our mission and to build an understanding of the Federal role in wildlife damage management.

INFORMATION SERVICES

This past year has been a busy and productive one for the NWRC Information Services Unit. Staff members worked with WS headquarters staff and Legislative and Public Affairs (LPA) to produce the WS FY 2001 information reports, NWRC highlights report, and the NWRC Research Update (our newsletter). Staff hosted numerous tours of the NWRC headquarters facility and provided information about the NWRC and WS program to Center visitors. The WS image database project was completed, and copies of the database and index were distributed to WS field stations and State offices. The database contains more than 2,000 scanned slides that illustrate the work of the WS program. A Web version of the database will be completed in 2003. The Information Services unit leader made a presentation at the 2002 Natural Resources Information Council meeting in Durango, CO, on the image collection. NWRC also participated in the CSU Natural Resources Career Fair and staffed a booth at the Denver Western Stock Show with WS Operations and LPA staff.

A total redesign of the NWRC Web site was a major highlight of the year. A new template was constructed to provide a more contemporary, standardized look. Interactivity was enhanced by adding a

search engine to the site. A clickable field station map and site map were also added. Both have enhanced site navigability for users. New pages were built and old pages restructured to enhance accessibility for disabled persons. An HTML copy of this report for FY 2001 was posted. About 60 NWRC publications were scanned and added as full-text documents. History features on Edwin R. Kalmbach, the role of WS during World War II, and early publications of the Biological Survey are also available now. Abstracts, agendas, and author instructions pages have been produced for the next NWRC symposium, "Management of North American Blackbirds." Staff has begun upgrading and adding to the wildlife damage images page, and numerous new links have been added to the reference and general links pages. Redesign and updating of content of all research project pages is underway.

All papers from the Proceedings of the ninth Wildlife Damage Conference were indexed in ProCite™ and integrated with previous proceedings, and all NWRC publications produced during the year were subject-indexed and added to the library catalog. An article on nicarbazin produced by library staff was published in "Inside APHIS," the agency newsletter.

Library—Library staff made significant strides this year in enhancing current awareness capabilities, reducing the cataloging backlog, and upgrading the NWRC Web site. Almost 300 new items were added to the NWRC catalog—a mix of old and new materials including theses, dissertations, reports, proceedings, and reference items. The Web interface for the library catalog was substantially upgraded by the vendor, and the new software is now operational for all Web users. Additionally, records of journals subscribed to by the library have been integrated into the main catalog. Finally, the process for labeling newly cataloged items has been automated, not only saving time but also ensuring accuracy of the information.

Several new online subscriptions were added, including the Code of Federal Regulations and WildPro™, a veterinary science database on wildlife diseases. A new site license allows for electronic delivery of journal tables of contents. More than 40 WS staff have taken advantage of this service which enables recipients to receive tables of contents from up to 50 journals. Overall reference information requests totaled nearly 400, with almost a third of the requests arriving via e-mail on the NWRC Web site. Online searches

performed by library staff numbered around 125. The library staff produced 328 information packets for visitors and conference or seminar participants and provided audiovisual support and videotaping for 30 seminars.

Employees borrowed almost 1,300 items from other libraries in response to information requests and lent more than 200 items in return. Additionally, staff photocopied 6,500 journal articles and reports for distribution to NWRC researchers and WS operations staff. FY 2002 saw a large increase in number of NWRC information products distributed: more than 11,400 items were mailed.

Library staff participated in the 33rd annual Colorado Interlibrary Loan Conference in Aspen, and a staff member attended the Institute for Federal Library Technicians in Washington, DC, for training in Federal library methods and procedures. A tour of the Library of Congress was included in the trip.

Archives—For the first time at NWRC, the Archives staff conducted Archive Week from October 22 to 26, 2001. Activities included daily e-mails regarding NWRC history and an Archive Open House on October 24. The last activity was a presentation on October 25 by retiree Bob Phillips that involved showing video tapes of Mutual of Omaha's

Wild Kingdom programs that detailed NWRC research in the 1970s and '80s.

Also for the first time, the Archives staff held a Records Management Week April 15–19, 2002. Highlights of the week included several e-mails regarding records management not only at NWRC but on a personal level. In addition, a “test your records knowledge” quiz was developed and a prize given to the person who gave the most right answers. Both Archives Week and Records Management week provided the staff with a glimpse into NWRC archival material and records management activities.

Visual Images—The Archives staff completed a digitalization project originally begun by APHIS LPA. By the end of 2001, the 2,000 digitized images were subject-indexed and entered into a database program usable agencywide. Later in the spring of 2002, CDs with the images and a searchable database were made available to every Wildlife State office.

A CSU public history student finished an inventory of a small collection of NWRC's many slides. The images were entered into a searchable database, indexed, and placed in appropriate slide holders for easy access and preservation.

History Features—In January 2002, the second exhibit was installed in a display

case in the main hall of the NWRC Wildlife Science Building. The topic, “Creating Solutions: the Analytical Chemistry Project at NWRC,” featured the Center's past and present chemistry work. Topics included exploratory chemistry, methods development, formulation chemistry, and wildlife genetics/molecular biology.

July 2002 saw the third display installed with a definite tropical theme. “Silent Invaders: NWRC Work on Brown Treesnakes on Guam” contained not only information on past and current work but featured an interactive computer component of audio interview clips and BTS surveillance footage. Plants around the case helped to give the feel of Guam's environment.

General Archival and Records Management Work—The records management and archives staff continues to rebox collections as needed to protect the records and make them more accessible. A major project involves NWRC unpublished material that was transferred to the National Archives and Records Administration's Rocky Mountain Region branch. Through a memorandum of understanding, NWRC regularly receives the records, provides holdings maintenance, and updates the NWRC catalog to better organize the material.

SEMINARS

The NWRC seminar program offers a valuable forum for the exchange of ideas among Center staff, field station personnel, visiting scientists, and WS staff. During the past year, NWRC hosted 19 seminars, including presentations by speakers from various corporate, State, and foreign wildlife organizations, NWRC headquarters and

field station staff, and potential candidates for employment. Presentations were videotaped and distributed to Center, field station, and WS regional offices for viewing. Topics included wildlife diseases, wildlife reproductive control, vertebrate pest control in New Zealand, and nonlethal approaches to resolving wildlife conflicts.

NWRC SEMINARS

Speaker	Affiliation	Topic
Robert Ellis	CSU, Fort Collins, CO	Current knowledge of prions and prion diseases: a synopsis
David Klein	University of Alaska, Fairbanks, AK	Aldo Leopold Lecture Series: Oil development and wildlife in the Alaska National Wildlife Refuge; changes in the north: A challenge for wildlife management
Brian Miller	Denver Zoo Denver, CO	Importance of large carnivores
Charles Stith	Arthropod-borne Animal Diseases Research Laboratory Laramie, WY	Reproductive control in coyotes
Arthur Dunham	University of Pennsylvania, Philadelphia, PA	Predicting population responses to environmental change: individual based, physiologically and spatially structured population models
Gary Witmer	NWRC, Fort Collins, CO	Rodent "tails" from the Caribbean
David Peacock	University of Adelaide Adelaide, AU	Chasing fluorine: native seed biochemicals potentially toxic to dogs and cats
Larry Clark	NWRC, Fort Collins, CO	Carriage of pathogenic bacteria by Canada geese in urban landscapes
Lowell Miller	NWRC, Fort Collins, CO	Induced infertility: mid-project review
Laura Simon	Fund for Animals	Nonlethal approaches for resolving wildlife conflicts
John Johnston	NWRC, Fort Collins, CO	Development of chemistry-based tools for wildlife damage management: midproject review
Philip Cowan	Landcare Research New Zealand, Ltd Palmerston North, NZ	Current issues in vertebrate pest control in New Zealand
David Ramsey	Manaaki Whenua Landcare Research Lincoln, NZ	Looking for a possum in a haystack: wildlife disease surveillance research in New Zealand
Steve Greiner	NWRC, Fort Collins, CO	My experience with the Virginia Avian Influenza Task Force
Bryan Kaphammer	USDA, Agricultural Research Service, Riverdale, MD	Technology transfer at USDA APHIS
Ray Sterner	NWRC, Fort Collins, CO	Economic methods project: mid-project review
Jimmy Taylor	NWRC, Starkville, MS	Dynamics of amphibian and avian diversity on Department of Defense land in east-central Mississippi
Gary Witmer	NWRC, Fort Collins, CO	Rodent damage management: midproject review
Nancy Rawson	Monell Chemical Senses Center, Philadelphia, PA	Feline chemosensation: what we know, what we don't know, what we can do about it

MEETINGS, WORKSHOPS, AND CONFERENCE PRESENTATIONS

Rabies in the Americas Conference—An NWRC biometrician presented a paper at the 12th Rabies in the Americas conference in Peterborough, Ontario, November 2002. This leading rabies conference was attended by people from 22 countries around the world. The NWRC scientist presented a paper evaluating population monitoring methods in support of the WS involvement with the trap, vaccinate, and release program for controlling rabies in skunks in Arizona.

Scientific Advisory Committee for the Management of the Puerto Rican Parrot—An NWRC researcher and the WS Florida State director represented WS on the Scientific Advisory Committee for the Management of the Puerto Rican Parrot. This parrot is critically endangered, and the interagency committee provides guidance on research and management aimed at protecting and conserving the species.

North Dakota Geographic Information System (GIS) Technical Committee—A scientist from the NWRC Bismarck, ND, field station, attended the spring 2002 meeting of the North Dakota GIS Technical Committee (GISTC). More than 40 people attended, representing GIS interests from Federal and State agencies, private industry, and State universities. GISTC's role is to coordinate and provide an overview of GIS activities within the State and to act as a clearinghouse for State GIS data and activities. Some of its goals are to set data exchange standards and eliminate redundancies in geospatial data collection. Data collection and its verification are major costs in GIS projects.

Idaho WS State Meeting—On June 5, 2002, a biologist from the NWRC Logan, UT, field station participated in the Idaho WS State meeting in Ketchum. Recent research findings about coyotes, wolves,

and jackrabbits relevant to the Idaho WS depredation management program were discussed with 33 employees of the Idaho program.

WS Michigan State Office Open House—A scientist from the NWRC Sandusky field station and the WS airport coordinator were among the attendees at the open-house ceremony for WS' new Gaylord, MI, office in June 2002. In light of the increasing concern over the burgeoning double-crested cormorant population on Lake Huron, the NWRC scientist was asked to present information on managing cormorants on the Great Lakes. The presentation stressed the need for a dynamic approach to evaluating management alternatives based upon a sound knowledge of the species' ecology and population demographics. The airport coordinator addressed the increasing need to manage wildlife to reduce bird strikes to aircraft as well as the need for WS leadership in this area.

Rodent Damage Model in Swine Production Facilities—An NWRC scientist

from Fort Collins, CO, participated in an interdisciplinary working group assembled to identify important variables and values associated with rodent damage and control in swine production facilities as part of an interactive computer model that incorporated knowledge from production models, scientific literature, and product literature. The model was presented at the June 2002 World Pork Exposition in Des Moines, IA, which was attended by pork producers and industry representatives from the United States and around the world. A Web-based version of the model can be found on the Internet Center for Wildlife Damage Management's Web site <http://wildlifedamage.unl.edu>.

Arizona WS State Meeting—Two NWRC scientists made research presentation at the Arizona WS meeting during June 2002. Attendees included 25 WS specialists, several tribal biologists representing the Navajo and Apache Nations and other Native American groups, and representatives of the Arizona Department of Fish and Game. Center presentations



included beaver damage management, bear damage management, M-44 updates and training, and an overview of ongoing research at NWRC.

Animal Behavior Concepts in Wildlife Damage Management Workshop—During June 2002, an NWRC scientist from Fort Collins presented a specialized training workshop to about 25 representatives from the law enforcement, parks and recreation, and animal control departments from several Colorado counties. The workshop, “Animal Behavior Concepts in Wildlife Damage Management,” addressed basic biological, ethnological, and behavioral concepts important to resolving diverse wildlife complaints and focused specifically on Colorado’s wildlife. This workshop represented several months of curriculum planning between NWRC and CSU cooperative extension agents.

Utah WS State Meeting—Three NWRC scientists attended the July 2002 Utah State WS meeting. The meeting was attended by 20 wildlife specialists, the Arizona WS State director, and the director of WS’ Western Region. The Center scientists presented an overview of NWRC research activities, an update on bovine TB and possible methods to mitigate its impact, and the results of recent studies on coyote vocalizations and trap shyness. Ways to facilitate communication about new research findings to the field were also explained.

Media Visit at Sandusky Field Station—The NWRC Sandusky field station hosted a television crew from a network station in Cleveland on June 28, 2002. The TV station did a feature story on aircraft collisions with birds (bird strikes) that aired in July. During a tour of the field station, the TV crew viewed Center research on repellent development and habitat management to reduce bird strikes, the use of lasers to disperse birds, and NWRC management of the National Wildlife Strike Database for the FAA.

Good Laboratory Practices (GLP) Training in Hawaii—Scientists at the

NWRC Hawaii field station are coordinating research to eradicate the recently introduced *Eleuthrodactylus* frogs from the Hawaiian Islands. This invasive species is a threat to endangered species, tourism, and agriculture. Caffeine is being evaluated as a pesticide to control the frogs, and GLP are critical to ensure proper data collection for the registration process. In July 2002, NWRC’s quality assurance officer and field station personnel offered GLP training to all State and Federal agencies in Hawaii involved with invasive species research. The 22 attendees represented 8 Federal and State agencies, including the Hawaii Department of Agriculture, the University of Hawaii Agriculture Research Center, the University of Hawaii Extension Service, the Maui Invasive Species Committee, the U.S. Geological Survey’s Biological Research Division, and the USDA Agricultural Research Service, as well as NWRC and WS operations.

Society for Conservation Biology—In July 2002, an NWRC scientist attended the annual meeting of the Society for Conservation Biology in Canterbury, UK. The scientist made a presentation to several hundred attending scientists on the development and evaluation on nonlethal techniques for managing predation and a lecture to the UK Wolf Conservation Trust that outlined the status and management of wolves in the United States.

Texas Sheep and Goat Ranchers Association Annual Meeting—In August 2002, a Utah State University graduate student working at the NWRC Logan field station attended the Texas Sheep and Goat Ranchers Association annual meeting in Kerrville, TX. The association has supported NWRC’s coyote reproductive inhibition research since 1995. The student spoke about NWRC’s reproductive inhibition research to 100 members of the association.

Mississippi WS State Meeting—During August 2002, NWRC biologists made presentations at the annual Mississippi WS

State meeting. The meeting was attended by 40 members of the WS program. Center presentations included briefings on aquaculture research being conducted at the Starkville, MS, field station, the NWRC mammal program, and NWRC’s rodent research projects. During the week, the NWRC scientists also met with the southern forest wildlife manager for Weyerhaeuser Timber Products, the department head and several faculty of the Wildlife and Fisheries Department, and the Dean of the College of Forest Resources at Mississippi State University.

Hobe Sound National Wildlife Refuge, Florida Award—A scientist from the NWRC in Fort Collins, CO, the WS Florida State director, and a WS wildlife specialist from Florida were invited to attend ceremonies at the Comprehensive Conservation Plan Issues meeting for Hobe Sound National Wildlife Refuge, FL, on July 31, 2002. At that meeting, all three were presented with certificates from the FWS in recognition of their contributions toward greatly reducing depredations of sea turtle nests by raccoons and armadillos. The collaborative effort among the three WS personnel has been directed at managing predators to maximally protect the nests of the threatened and endangered sea turtles.

“The Carnivores” Summer Program—A graduate student working at the NWRC Logan field station served as the primary coordinator for a summer lecture series on carnivores organized especially for senior citizens who spend the summers in and around Logan. On August 5, 2002, a biologist from the field station initiated the lecture series with a presentation on coyotes to about 30 people, covering aspects of coyote biology, behavior, population processes, predator–prey relationships, and depredation management. This is the second year personnel from the Logan field station have made significant contributions to the program.

PUBLICATIONS

[**Boldface** type indicates an NWRC author.]

Ahmed, Md. S.; **Fiedler, L. A.** 2002.

A comparison of four rodent control methods in Philippine experimental rice fields. *International Biodeterioration and Biodegradation* 49: 125–132.

Avery, M. L.; Humphrey, J. S.; Tillman, E. A.; Phares, K. O.; Hatcher, J. E. 2002. Dispersing vulture roosts on communication towers. *Journal of Raptor Research* 36(1): 45–50.

Barras, S. C.; Wright, S. E. 2002. Civil aircraft collisions with birds and other wildlife in Ohio, 1990–1999. *Ohio Journal of Science* 102(2): 2–7.

Blackwell, B. F.; Bernhardt, G. E.; Dolbeer, R. A. 2002. Lasers as nonlethal avian repellants. *Journal of Wildlife Management* 66(1): 250–258.

Blackwell, B. F.; Stapanian, M. A.; Weseloh, D. V. C. 2002. Dynamics of the double-crested cormorant population on Lake Ontario. *Wildlife Society Bulletin* 30(2): 345–353.

Blejwas, K. M.; Sacks, B. N.; **Jaeger, M. M.**; McCullough, D. R. 2002. The effectiveness of selective removal of breeding coyotes in reducing sheep predation. *Journal of Wildlife Management* 66(2): 451–462.

Bruggers, R. L.; Owens, R.; Hoffman, T. 2002. Wildlife damage management research needs: perceptions of scientists, wildlife managers, and stakeholders of the USDA/Wildlife Services program. *International Biodeterioration and Biodegradation* 49: 213–223.

Clark, L.; Shivik, J. 2002. Aerosolized essential oils and individual natural product compounds as brown treesnake repellants. *Pest Management Science* 58: 775–783.

Cleary, E. C.; **Wright, S. E.; Dolbeer, R. A.** 2002. Federal Aviation Administration national wildlife strike database. Serial Rep. 7. Washington, D.C.: Federal Aviation Administration. 36 pp. [Online at <http://wildlife-mitigation.tc.faa.gov/>]

Cummings, J. L.; Glahn, J. F.; Wilson, E. A.; Davis, Jr., J. E. 2002. Potential hazards of DRC-1339 treated rice to non-target birds when used at roost staging areas in Louisiana to reduce local populations of depredating blackbirds. *International Biodeterioration and Biodegradation* 49: 185–188.

Cummings, J. L.; Pochop, P. A.; Engeman, R. M.; Davis, Jr., J. E.; Primus, T. M. 2002. Evaluation of Flight Control® to reduce blackbird damage to newly planted rice in Louisiana. *International Biodeterioration and Biodegradation* 49: 169–173.

Engeman, R. M.; Sterner, R. T. 2002. A comparison of potential labor-saving sampling methods for assessing large mammal damage in corn. *Crop Protection* 21: 101–105.

Engeman, R. M.; Engeman, I. M.; Engeman, A. N. 2002. *Thamnophis radix* (Plains garter snake) brood size. *Herpetological Review* 33(1): 59.

Engeman, R. M.; Maedke, B. K.; Beckerman, S. F. 2002. Estimating deer damage losses in cabbage. *International Biodeterioration and Biodegradation* 49: 205–207.

Engeman, R. M.; Peterla, J.; Constantin, B. 2002. Methyl anthranilate aerosol for dispersing birds from the flight lines at Homestead Air Reserve Station. *International Biodeterioration and Biodegradation* 49: 175–178.

Engeman, R. M.; Pipas, M. J.; Gruver, K. S.; Bourassa, J.; Allen, L. 2002. Plot placement when using a passive tracking index to simultaneously monitor multiple species of animals. *Wildlife Research* 29: 85–90.

Engeman, R. M.; Vice, D. S.; York, D.; Gruver, K. S. 2002. Sustained evaluation of the effectiveness of detector dogs for locating brown tree snakes in cargo outbound from Guam. *International Biodeterioration and Biodegradation* 49: 101–106.

Fall, M. W.; Jackson, W. B. 2002. The tools and techniques of wildlife damage management—changing needs: an introduction. *International Biodeterioration and Biodegradation* 49: 87–91.

Glahn, J. F.; Dorr, B.; Harrel, J. B.; Khoo, L. 2002. Foraging ecology and depredation management of great blue herons at Mississippi catfish farms. *Journal of Wildlife Management* 66(1): 194–201.

Glahn, J. F.; Dorr, B. S. 2002. Captive double-crested cormorant *Phalacrocorax auritus* predation on channel catfish *Ictalurus punctatus* fingerlings and its influence on single-batch cropping production. *Journal of the World Aquaculture Society* 33(1): 85–93.

Green, J. S.; **Knowlton, F. F.; Pitt, W. C.** 2002. Reproduction in captive wild-caught coyotes (*Canis latrans*). *Journal of Mammalogy* 83(2): 501–506.

Homan, H. J.; Linz, G. M.; Engeman, R. M.; Penry, L. B. 2002. Spring dispersal patterns of red-winged blackbirds staging in east-central South Dakota. In: *Proceedings of the 24th sunflower research workshop*; 17–18 January 2002; Fargo, ND. Bismarck, ND: National Sunflower Association: 155–158.

- Kimball, B. A.;** Provenza, F.; Burritt, E. A. 2002. Importance of alternative foods on the persistence of flavor aversions: implications for applied flavor avoidance learning. *Applied Animal Behaviour Science* 76 : 249-258.
- Knowlton, F. F.;** Ebbert, S. M. 2002. Disposition of fluid from Livestock Protection Collars following coyote attacks on collared goats. *International Biodeterioration and Biodegradation* 49: 199-204.
- Kullas, H.;** **Coles, M.;** Rhyan, J.; **Clark, L.** 2002. Prevalence of *Escherichia coli* serogroups and human virulence factors in faeces of urban Canada geese (*Branta Canadensis*). *International Journal of Environmental Health Research* 12: 153-162.
- Linz, G.;** Kenyon, M. J.; **Homan, H. J.;** Bleier, W. J. 2002. Avian use of rice-baited corn stubble in east-central South Dakota. *International Biodeterioration and Biodegradation* 49: 179-184.
- Linz, G. M.;** **Barras, A. E.;** Sawin, R. S.; Bleier, W. J.; **Homan, H. J.;** Bergman, D. L.; **Penry, L. B.** 2002. Baiting blackbirds during spring migration in South Dakota. In: Proceedings of the 24th sunflower research workshop; 17-18 January 2002; Fargo, ND. Bismarck, ND: National Sunflower Association: 143-147.
- Mason, J. R.;** **Pitt, W. C.;** Bodenchuk, M. J. 2002. Factors influencing the efficiency of fixed wing aerial hunting for coyotes in the western United States. *International Biodeterioration and Biodegradation* 49: 189-197.
- Mauldin, R. E.;** **Primus, T. M.;** **Volz, S. A.;** **Kimball, B. A.;** **Johnston, J. J.;** **Cummings, J. L.;** **York, D. L.** 2002. Determination of anthraquinone in technical material, formulations, and lettuce by high performance liquid chromatography. *Journal of Agricultural and Food Chemistry* 50(13): 3632-3636.
- Miller, L. A.;** Killian, G. 2002. In search of active PZP epitope in white-tailed deer immunocontraception. *Vaccine* 20: 2735-2742.
- Moser, B. W.; **Pipas, M. J.;** **Witmer, G. W.;** **Engeman, R. M.** 2002. Small mammal use of hybrid poplar plantations relative to stand age. *Northwest Science* 76(2): 158-165.
- Nolte, D. L.;** **Veenendaal, T. J.;** Ziegler, G. J.; Fersterer, P. 2002. Bear behavior in the vicinity of supplemental feeding stations in western Washington. *Western Black Bear Workshop* 7: 106-111.
- Pitt, W. C.;** Ritchie, M. E. 2002. Influence of prey distribution on the functional response of lizards. *Oikos* 96: 157-163.
- Ramey, C. A.;** **Matschke, G. H.;** **Engeman, R. M.** 2002. Seasonal marking efficacy of Dupont oil blue A dye on steam-rolled oat groat baits for valley pocket gopher. *International Biodeterioration and Biodegradation* 49: 163-167.
- Ramey, C. A.;** **Matschke, G. H.;** **Hegdal, P. L.;** **McCann, G. R.;** **Engeman, R. M.** 2002. Safe efficacy of three strychnine alkaloid bait concentrations for hand-baiting control of plains pocket gophers. *International Biodeterioration and Biodegradation* 49: 139-143.
- Safratowich, B. D.; **Linz, G. M.;** Bleier, W. J.; Lee, C. J. 2002. Avian use of roadside habitat and implications for cattail management. In: Proceedings of the 24th sunflower research workshop; 17-18 January 2002; Fargo, ND. Bismarck, ND: National Sunflower Association: 135-138.
- Santisteban, L.; Sieving, K. E.; **Avery, M. L.** 2002. Use of sensory cues by fish crows *Corvus ossifragus* preying on artificial bird nests. *Journal of Avian Biology* 33: 245-252.
- Sawin, R. S.; **Linz, G. M.;** Bleier, W. J. 2002. Improving blackbird population control with targeted baiting programs: biological considerations. In: Proceedings of the 24th sunflower research workshop; 17-18 January 2002; Fargo, ND. Bismarck, ND: National Sunflower Association: 148-150.
- Schaaf, D. A.; **Linz, G. M.;** Bleier, W. J. 2002. Factors affecting avian use of ripening sunflower fields. In: Proceedings of the 24th sunflower research workshop; 17-18 January 2002; Fargo, ND. Bismarck, ND: National Sunflower Association: 139-142.
- Schauster, E. R.; **Gese, E. M.;** **Kitchen, A. M.** 2002. Population ecology of swift foxes *Vulpes velox* in southeastern Colorado. *Canadian Journal of Zoology* 80: 307-319.
- Smith, G. W.; **Stoddart, L. C.;** **Knowlton, F. F.** 2002. Long-distance movements of black-tailed jackrabbits. *Journal of Wildlife Management* 66(2): 463-469.
- Stahl, R. S.;** Custer, T. W.; **Pochop, P. A.;** **Johnston, J. J.** 2002. Improved method for quantifying the avicide 3-chloro-p-toluidine hydrochloride in bird tissues using a deuterated surrogate/GC/MS method. *Journal of Agricultural and Food Chemistry* 50(4): 732-738.
- Stahl, R. S.;** **Johnston, J. J.** 2002. High-performance liquid chromatography-based determination of nicarbazin excretion in waterfowl. *Journal of Chromatography B* 775 : 103-108.
- Sterner, R. T.;** **Ames, A. D.;** **Kimball, B. A.** 2002. Persistence of capsicum oleoresin in soil. *International Biodeterioration and Biodegradation* 49: 145-149.
- Sterner, R. T.;** **Petersen, B. E.;** **Shumake, S. A.;** **Gaddis, S. E.;** **Bourassa, J. B.;** **Felix, T. A.;** **McCann, G. R.;** **Crane, K. A.;** **Ames, A. D.** 2002. Movements of a bullsnake *Pituophis catenifer* following predation of a radio-collared northern pocket gopher *Thomomys talpoides*. *Western North American Naturalist* 62(2): 240-242.
- Sterner, R. T.;** **Ramey, C. A.** 2002. An index technique to monitor broadcast calibration and bait pick up, plus rodent and avian sign under arid conditions. *Pest Management Science* 58: 385-391.

Stewart, W. B.; **Witmer, G. W.; Koehler, G. M.**; Norton, M. 2002. Incisor analysis technique to predict the gender of black bears damaging trees. *International Biodeterioration and Biodegradation* 49: 209-212.

Tobin, M. E.; King, D. T.; Dorr, B. S.; Werner, S. J.; Reinhold, D. S. 2002. Effect of roost harassment on cormorant movements and roosting in the Delta Region of Mississippi. *Waterbirds* 25(1): 44-51.

Twedt, D. J.; **Linz, G. M.** 2002. Morphometric changes in yellow-headed blackbirds during summer in central North Dakota. *Western North American Naturalist* 62(1): 39-43.

Volz, S. A.; Johnston, J. J. 2002. Solid phase extraction/gas chromatography/electron capture detector method for determination of organochlorine pesticides in wildlife and wildlife food sources. *Journal of Separation Science* 25: 119-124.

Wimberly, R. L.; Linz, G. M.; Bleier, W. J.; Homan, H. J. 2002. Landscape effects on breeding blackbird abundance and sunflower damage in the southern drift plains of North Dakota. In: *Proceedings of the 24th sunflower research workshop*; 17-18 January 2002; Fargo, ND. Bismarck, ND: National Sunflower Association: 152-154.